Austrian Special Report 2018 (ASR18)

Summary for Policymakers and Synthesis

Austrian Panel on Climate Change (APCC)

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Austrian Special Report

Health, Demography and Climate Change

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(ASR18)

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Willi Haas, Hanns Moshammer, Raya Muttarak, Olivia Koland

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As early as in the mid 1980s it became clear
that the climate crisis would not come as a slow, linear development,
but would rather turn into a global challenge at a rapid pace.
In the meantime, the effects are being clearly seen and felt across the globe.
The primary objective is still to reduce greenhouse gas emissions.
But we already have to protect ourselves against the health effects of climate change.
Great heat, extreme drought, heavy precipitation, hurricanes, floods, and, of course,
also the indirect consequences of these phenomena are affecting all of us, humankind as a whole.
In addition to scientific findings,
an adequate response to the climate crisis also requires political action:
in international politics, European politics, national, regional and local politics.
I believe no one has any illusions about how difficult it is
to take political action that is geared towards the urgently needed transition to a different,
ecologically oriented, climate-friendly and health-promoting global society.
This Austrian Special Report now presents a coordinated scientific assessment that provides a basis
for far-reaching political decisions.
I wish for this report, and for the sake of all of us, that political action will follow.
I would like to thank all the authors
in their various roles, the review management, reviewers and international review editors,
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for their dedicated, future-oriented contributions.

Federal Minister for Sustainability and Tourism

Climate change has arrived in our midst; its effects are already being clearly felt.

Glaciers are melting, the sea level is rising, heat waves, droughts and other extreme weather events are on the increase across the globe. The consequences already have a massive impact on people's lives and their economic activities. The effects on human health are evident and are the subject of this report. Climate protection also entails doing something beneficial for our own health.

The Austrian Federal Government attaches great importance to climate protection. With #mission2030, the Austrian Climate and Energy Strategy, we have laid the foundation for numerous measures and strategies that are now being implemented and represent steps in the right direction. Through the klimaaktiv participatory climate protection initiative we support businesses, households and municipalities in putting effective climate protection measures into practice.

Climate protection is a huge challenge that will remain an issue for generations to come. Effective climate protection is based on the two pillars of energy efficiency and renewable energies. It affects all areas of life - how we live, work, dwell and move. In the long run, the costs for the protection of our climate will be significantly lower than those caused by unchecked global warming. Thus, it is all the more important for us to systematically consider the consequences of climate change in all relevant planning and decision-making processes now.

For many years already, Austria has intensified its efforts in dealing with the question of how to best respond to climate change. In this study, commissioned by the Austrian Climate and Energy Fund, profound facts have been produced. What we need now are specific solutions to be prepared for the future. We must resolutely implement Austria's strategy for adapting to climate change, jointly supported by the federal and state governments, and prepare ourselves for future challenges in the best way possible.

Summary for Policymakers

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Key Statements

Climate change and its health effects

- The health consequences of climate change are already being felt today and are to be considered an increasing threat to health.
- The most severe and far-reaching health effects are to be expected as a consequence of heat.
- Climate change leads to increased health effects associated with pollen (allergies), precipitation, storms and mosquitoes (infectious diseases).
- Demographic change (e.g. aging) increase the population's vulnerability and thus intensify climate-induced effects on health.

Addressing the health effects of climate change and reducing vulnerability

- **Heat:** Heat warning systems complemented by action-oriented information for persons who are hard to reach can become effective at short notice; urban development measures have a long-term effect.
- **Allergens:** Fighting highly allergenic plants reduces health effects and therapy costs.
- **Extreme precipitation, drought, storms:** Integrated event documentation for more targeted measures, strengthening self-provision and involvement of diverse groups in the preparation of contingency plans can help lessen the impact.
- **Infectious diseases:** Promoting capacities in early detection among the population and health staff for preventive purposes; targeted control of invasive species in order not to endanger other species.
- Growing **health inequality** of vulnerable groups induced by climate change can be avoided by strengthening health literacy.
- Promoting **climate-specific health literacy** of health staff as well as enhancing the **quality of dialogue** with patients for the individual handling of climate change and developing healthier and more sustainable lifestyles (diet, exercise).
- Systematically promoting children's/young persons' **education and training** to develop an understanding of climate and health-relevant issues, allowing them to act accordingly.

Leveraging opportunities for climate and health

- **Diet:** The positive implications of a reduction in excessive meat consumption in particular are considerable in terms of climate protection and health, with comprehensive sets of measures, including price signals, showing positive effects.
- **Mobility:** A shift to more active mobility and public transport, in particular in cities, reduces air and noise pollution and leads to healthy movement; reduction of climate-relevant air traffic also diminishes adverse health effects.
- **Housing:** The high percentage of newly built single-family and duplex houses is to be challenged as it uses a lot of space, materials and energy, and making apartment buildings attractive as an alternative to a house in a green area requires funding; pushing health-enhancing and climate-friendly urban planning; thermal renovation reduces the heat stress during the summer half-year.
- **Health sector:** The climate-relevance of this sector makes a specific climate strategy necessary; pharmaceutical products are responsible for a major share of the carbon footprint; avoiding unnecessary diagnostics and therapies reduces greenhouse gas emissions, risks for patients and health-related costs.

Initiating transformation at the intersection of climate and health

- **Cross-policy collaboration in the field of climate and health policies** represents an appealing opportunity to simultaneously implement Austria's Health Targets, the Paris Climate Agreement and the United Nations Sustainability Goals.
- **Harnessing the scientific potential for transformation:**
  - Innovative methods in science, like, for instance, transdisciplinary approaches, can trigger learning processes and make accepted problem-solving more likely.
  - Research in medicine and agriculture has to become more transparent (funding and methods); issues such as the reduction of over-medication and multiple diagnoses or the health-related assessment of organic food require independent funding.
  - Learning from health promoting and climate-friendly everyday practices of local initiatives, like, for instance, eco-villages, slow food, slow city movements and transition towns.
  - Transformation research and research-oriented teaching accelerate transformative development paths and encourage new interdisciplinary solutions.

1 Challenge and Focus

The effects of climate change on health are already being felt today. Based on current projections of future climate trends, it is to be expected that the world population will have to face unacceptably high health risks. This is obvious from both the most recent report of the IPCC as well as more recent papers published by leading experts. In Austria, the effects of climate change can already be observed and are to be considered a growing threat to health, which will be further intensified by demographic change.

The assessment presented here summarizes the state of scientific knowledge on the topics of "climate-health-demography". The assessment starts out with the issues of climate, population, economy and health care as interacting determinants of health (Fig. 1). In this context, climate change either has direct effects on health, like, for instance, during heat waves, or indirectly through changing natural systems, such as through an increased release of allergens or more favorable living conditions for disease-transmitting organisms. The extent to which climate change will eventually affect health, however, can be estimated only in combination with population dynamics, economic development and health care. A higher proportion of elderly people or of the chronically ill, poorer health care or also an increasing number of people with lower income lead to a higher level of vulnerability of society to climate change.

There are various options for action available to the government as well as businesses and individuals. If the goal is to create a largely climate-neutral society, it seems necessary to make use of a multitude of these options for action. In addition to individual climate protection measures, however, a more extensive transformation toward a climate-friendly society is necessary that addresses the underlying causes of climate change. This approach often entails an added health benefit of climate protection measures (co-benefits). At the same time, in light of progressing climate change, measures to adapt to climate change have to be taken to minimize the adverse consequences for health.

In order to make a reliable assessment of these complex causal relationships that are also relevant to Austria, a transparent process, comprehensive in terms of content and taking account of an interdisciplinary balance, was implemented for the preparation of an Austrian Special Report following the style of the Austrian Assessment Report Climate Change (AAR14) and the reports of the Intergovernmental Panel on Climate Change (IPCC). More than 60 scientists made contributions as authors and another 30 as reviewers to provide a basis for decision-making in the fields of science, administration and politics, facilitating efficient and responsible action.

The key finding of this work of one and a half years is that a well-coordinated climate and health policy can be a powerful stimulus for transformation toward a climate-compatible society that promises a high level of acceptance owing to its potential to bring about better health and a higher quality of life for all.

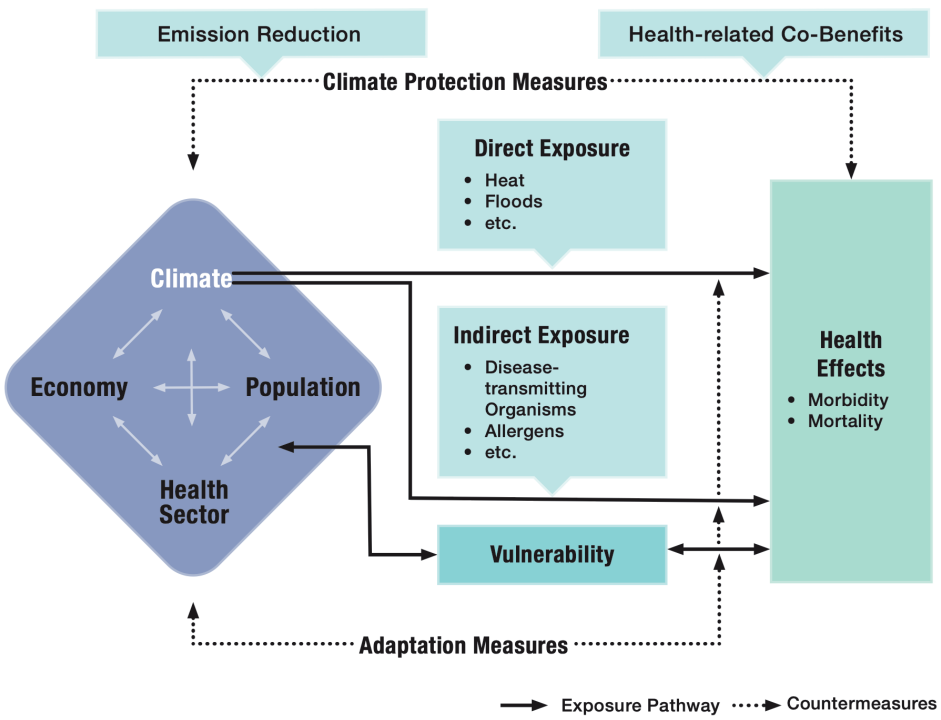


Fig. 1: Dynamic model how changes in health determinants affect health.

2 Health-relevant Changes in the Climate

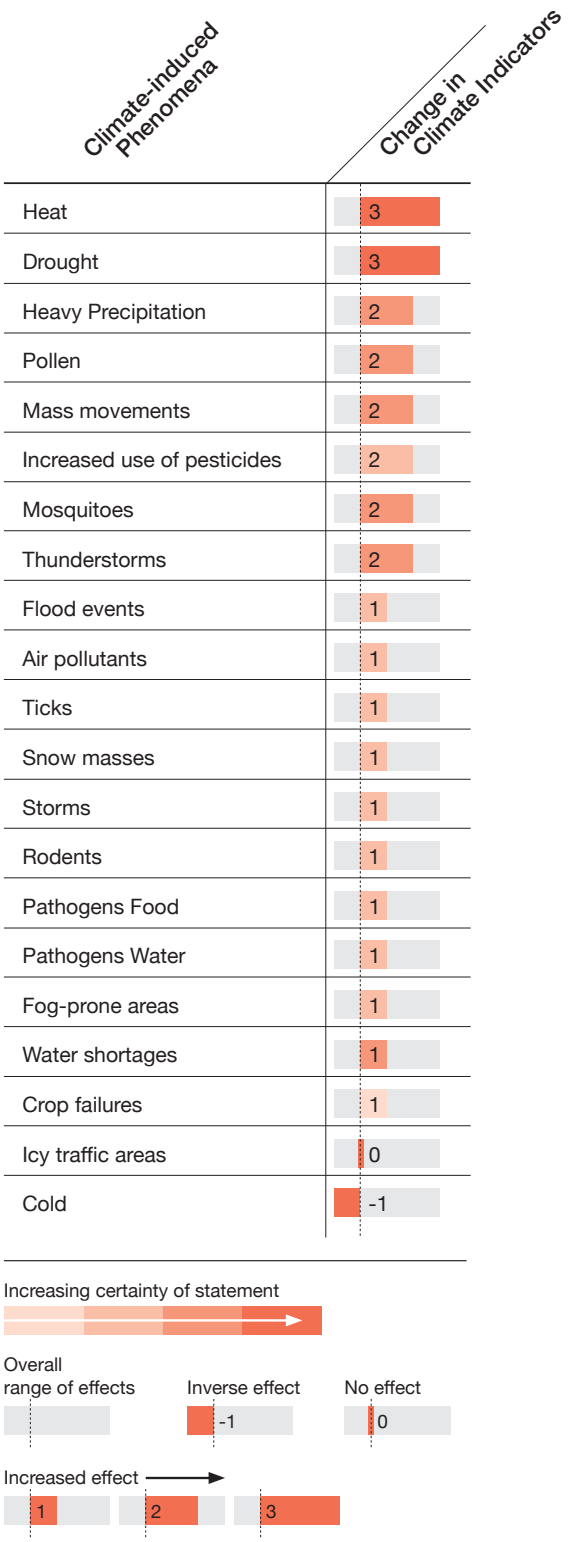


Fig. 2: Assessment of climate-induced changes in health-relevant phenomena with a time horizon until 2050 (3 = major adverse changes)

To better understand the health-related relevance of climate change in a first step, those climatic phenomena which have an effect on health were identified. For this purpose, climatologists made an estimation of the climatic changes to be expected by 2050, initially without taking into account how many persons will be affected and to what extent. In doing so, the uncertainty of the statement with regard to climate change was also taken into consideration (Fig. 2).

The most severe changes posing the greatest threat to health are to be expected during heat waves, both because of the steady rise in temperature during the summer half-year, the number of hot days, the duration of the heat events and a less pronounced drop in temperature at night. Drought also falls into the category of major changes. In this context, however, it turns out that owing to its sound food supply, Austria will presumably see only minor health effects. Both during heat and drought the climatological statements show high certainties. With regard to severity and certainty of statement, extreme precipitations are rated slightly lower. Based on reliable statement, an increasing incidence of allergies is rated as highly relevant, with prolonged seasons, an increased occurrence of already indigenous allergenic plants and migration of new allergenic plant and animal species expected with medium certainty. In all areas mentioned, climate change leads to an aggravation of adverse health effects – except for the cold. The number of cold days is declining, the duration of cold periods is decreasing and it is highly certain that average temperatures will rise during the winter half-year. Thus, it can be inferred that the number of cold-related conditions and/or cold-related deaths will decrease, which, however, will not outweigh the adverse effects of an increased number of heat waves. In addition, there is a risk not described here, i.e. that the melting of the arctic ice and a resulting slowdown of the Gulf Stream may lead to longer and colder winters with an increased number of cold-related deaths also in Austria.

For all climatic phenomena outlined here, the consequences may differ strongly from region to region and may be different in rural areas and in metropolitan areas.

3 Priorities regarding Climate-induced Health Effects

To allow a better classification of the urgency regarding the various health-relevant developments, based on their state of knowledge, 20 key experts of the Assessment Report evaluated them based on two groups of criteria:

- Affected persons: proportion of affected persons among the population taking into account socio-economically disadvantaged groups and vulnerable persons, such as infants, elderly people and persons with pre-existing illnesses.
- Health effects: mortality, physical and mental morbidity

According to this assessment, the highest priority is to be given to situations where the combined effect of both criteria groups occurs, i.e. when a relatively high percentage of the population has to expect serious health effects. The differing estimates within the individual criteria explain the grading of the ascribed priority levels. In addition, possible options for action at individual and government level (the latter also includes the health care system) were assessed. This expert assessment is to be seen as cross-topic and thus integrative guidance – it cannot replace a strictly scientific analysis.

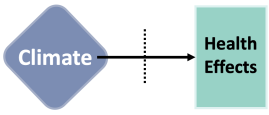
The assessments showed a clear categorization into three priority levels according to which the individual issues should be addressed (Fig. 3): Heat is at the top of the table with the highest priority, followed by pollen and air pollutants together with extreme events such as heavy precipitation, drought, flood events, mudslides and landslides. Little significance, on the other hand, is attributed to cold-related events, shortage of water or food and pathogens in water and food. The high priority assigned to the group of "air pollutants" is remarkable, although uncertainties as to further developments are high. As the collective term comprises both ozone (upward tendency) and particular matter concentrations (downward tendency) the findings are hard to interpret. The events particularly affecting economically disadvantaged persons as well as elderly and ill persons mainly fall into the highest priority category. Any adverse health effects of crop failures are less likely in Austria on account of the favorable supply situation – if necessary, supported by imports.

Figure 3 clearly shows that both at individual and government level options for action are identified – generally more at government level. No differentiation was made between these as to their nature, i.e. preventive measures, crisis interventions and follow-up measures are included. Not all measures are part of the health care system, as the example of an imminent increased use of pesticides in farming shows. Only in one single case is the individual person thought capable of dealing with more options for action than the government – namely in connection with icy traffic areas.

In the statements below, special attention is paid to the fact that many of the measures that are important in terms of climate protection have positive "side effects" (co-benefits). This is especially true for health, which is why the measures are warranted even in the absence of any climate effect.

Fig. 3: Assessment of impacts of climate-induced phenomena on health with a time horizon until 2050 (3 = major adverse changes) for a share of the affected population as well as the extent of health effects sorted by urgency categories (3 = highest need for action)

4 Mitigating Health Effects



This section summarizes the developments and effects of the most pressing climate-induced health effects as well as options for action for their prevention with regard to Austria. Moreover, it addresses basic strategies for dealing with increased vulnerability due to demographic dynamics as well as ways and means of reducing vulnerability.

4.1 Addressing Climate-induced Effects

Heat

Climate: By the middle of this century, it is to be expected that the number of hot days, i.e. days during a heat episode (periods with daily maximums of 30 °C and above), will double; by the end of the century, if no sufficient climate protection measures are taken, there may be a tenfold increase in the number of hot days. Less of a drop in evening temperatures also adds to the problem; the number of nights during which temperatures do not fall below 17 °C has gone up by 50 percent in Vienna (comparison of 1960–1991 and 1981–2010) (high agreement, robust evidence).

Health: Assuming that no further adaptation is made and climate change will be moderate, 400 heat-related deaths per year can be expected in Austria in 2030; by mid-century, this number could rise to 1,000 cases per year, with the major share occurring in cities (according to more recent climate projections, 2030 could see even higher figures). Elderly people and persons with pre-existing illnesses are particularly vulnerable, economically weaker persons and/or migrants are often more strongly affected due to their housing situation (densely built-up areas, few green areas) (high agreement, medium evidence).

Options for action: Swift implementation of urban development measures to alleviate the problem of urban heat islands, planting trees, enhanced air circulation, reduction of the thermal load of heat-generating sources, facilitating cooling down at night, reduction of air pollutants and noise pollution allowing rooms to be aired at night may lead to significant improvements in the long run and may help avoid energy-consuming air conditioning that is potentially harmful to the climate. In the short term, an evaluation of the heat warning systems may be advisable, by focusing in particular on action-oriented information of persons who are hard to reach (e.g. elderly people without Internet access or persons with language barriers) in cities (high agreement, robust evidence).

Allergens

Climate: Climate change in combination with globalized trade and travel as well as land use change lead to the spread of plant and animal species that were previously not indigenous, but that have an impact on health. A significant increase in the pollen count caused by ragweed (*Ambrosia artemisiifolia*) is expected, which is enhanced by increased air humidity as well as the "fertilizing effect" of CO_2 and nitrogen oxides. The German Assessment Report expects the emergence of another six new plant species with clear potential for being harmful to health. In urban areas in particular, the concentration of pollen in the air has surged (high agreement, robust evidence).

Health: As a consequence, the number of respiratory diseases (hay-fever, asthma, COPD) is rising. Increased health effects can be expected particularly in urban areas in combination with air pollutants (ozone, nitrogen oxides, particulate matter, etc.) as they lead to an increased allergenic aggressiveness of pollen. Even today, approximately 1.75 million people in Austria suffer from allergic diseases. The frequency and severity of allergies will increase. According to estimates, 50 percent of all Europeans will be affected in 10 years' time (high agreement, medium evidence).

Options for action: Planned nationwide monitoring can alleviate adverse effects through targeted information. By consistently fighting highly allergenic plants (e.g. mowing or weeding before seed formation in *Ambrosia*), health effects can be avoided and considerable therapy costs can eventually be saved. This is, for instance, documented in analyses of the health effects of the spread of *Ambrosia* in Austria and Bavaria (high agreement, medium evidence). The incorporation of control measures into law, and the involvement of key stakeholders, can contribute significantly to the reduction of the health effects caused by *Ambrosia* in Austria.

Extreme precipitation, drought, storms

Climate: For physical reasons, more intense and abundant rainfall, longer periods of draught and heavier storms can be expected in the wake of climate change (medium agreement, medium evidence). Even today, costs for damage caused by extreme events are considerable in Austria, and soaring.

Health: Extreme weather events make good headlines, but the number of people exposed to them is – disregarding extreme temperature events – relatively small, thus the immediate health effects of extreme weather phenomena in Austria are relatively low (high agreement, medium evidence). Nevertheless, extreme events can cause immediate health effects, such as injuries or deaths and, in particular in the case of existence-threatening material damage, post-traumatic stress disorders. Indirectly, poor water quality following floods can trigger bacterial infections. Extreme weather events occurring in other countries may lead to (climate-induced) migration;

presently, however, this is not considered a serious threat to the Austrian population's health thanks to the high standard of Austria's health care system.

Options for action: An integrated event documentation (merging of the reliable records on the initial situation, causes, measures, effects) can facilitate the analysis and preparation of bespoke measures (high agreement, medium evidence). Damage and health effects can be reduced further by strengthening self-provision and by well-coordinated collaboration in the risk management of public and private stakeholders. These can be supported by including them in school curricula, targeted information, advisory services and incentives for preventative disaster management, like, for instance, technical and financial support as well as reduced insurance premiums for well-prepared households. The involvement of a good mix of diverse groups can be beneficial in the preparation of effective disaster management plans, in particular at municipal level, as both their needs are taken into account and their potential is used in dealing efficiently with disasters (medium agreement, medium evidence).

Infectious diseases

Climate: Climate change (in particular global warming) will have an effect on the occurrence of mosquitoes as vectors of diseases, as subtropical and tropical mosquito species introduced to Austria (especially of the *Aedes* species: tiger mosquito, Asian bush mosquito, etc.) will find better survival conditions here in future. Thus, they will inhabit more extended areas, particularly spreading across the northern and altitudinal limits. Some of our indigenous mosquito species may also transmit pathogens of infectious diseases previously rarely seen in Austria, such as the West Nile virus or the Usutu virus. Moreover, an increased distribution of sand flies and wood ticks (*Dermacentor* ticks) as potential vectors of several infectious diseases (leishmaniasis, FSME virus, Crimean-Congo hemorrhagic fever virus, Rickettsia, Babesia, etc.) could be observed.

Health: The occurrence of infectious diseases is determined by complex interrelations, ranging from globalized traffic, people's temperature-dependent behavior and local weather factors (e.g. humidity) to the survival rate of infectious agents – depending on the water temperature (high agreement, medium evidence). The concrete relationships, however, have not yet been sufficiently studied to allow conclusive statements to be made. Furthermore, if global warming progresses, diseases related to food may occur (e.g. campylobacter and salmonella infections, contamination with mycotoxins); the high national food production standards, however, – in particular well-functioning cold chains – do not give us reason to expect any significant implications for the incidence of these diseases in Austria in the near future (high agreement, medium evidence).

Options for action: A pivotal factor in combating infectious diseases in time is early detection. This can be improved, on the one hand, by promoting the relevant health literacy among the population, and, on the other hand, by further developing professional competency in health professions, particularly in primary care. In doing so, the climate-induced infectious diseases that are essentially highly treatable can be detected quickly, despite their previously rare occurrence (high agreement, robust evidence). In this context, the reorientation of the public health service as laid down in *Zielsteuerung-Gesundheit 2017* (Target-based Health Governance) can have a supporting effect (establishing nationwide pools of experts in new infectious diseases). To achieve the best possible control measures, the evaluation and exchange of knowledge at international level are of vital importance. In addition, special attention has to be paid to the targeted fight against dangerous species in order not to deprive amphibians and other animals of their basic food resources by exterminating non-hazardous insects (e.g. non-biting midges) (high agreement, medium evidence). In the field of food, adapted food monitoring for climate change-related monitoring and – if necessary – adaptation of the guidelines regarding best agricultural and hygienic practices can contribute to health protection. It should be pointed out that the use of disinfectants can have negative effects on the environment and humans and is, in most cases, especially in households, absolutely unnecessary. There is a need for research with regard to possible extensions of propagation areas of potential vectors. A review of food monitoring and – if required – its adaptation in Austria by AGES can contribute further to food safety.

4.2 Reducing Vulnerability

Mitigating the Aggravating Effect of Demographic Change on Climate-related Health Effects

Development dynamics: Austria's population is growing mainly in the urban regions. On average, the aging of the population is characterized by a shrinking proportion of people of working age and a consistent proportion of children and adolescents. Aging is mitigated by the migration of young adults. The figures for the outskirts show a decline in population for educational and employment reasons, while at the same time the population is increasingly aging. In the long run, an annual migratory balance for Austria of approximately 27,000 additional people (period 2036–2040) is to be expected. While exact figures are uncertain, net migration is likely to increase (high agreement, robust evidence). It is to be assumed that the incidence rate of chronic diseases like, for instance, dementia, respiratory diseases, cardiovascular dis-

eases and malignant tumors (malignomas), including all health implications following in their wake, will go up. It is quite remarkable that the occurrence of more than half of all mental disease cases can be witnessed among the age group of over 60-year olds.

Relation to climate: Due to the high proportion of cardiovascular diseases, diabetes and mental diseases in people over 60 years of age, older population groups are especially vulnerable to the impact of climate change, in particular heat. In addition, future, more frequent extreme weather events are likely to lead to increased mental stress for elderly people. Persons with only few resources at their disposal are particularly susceptible to the negative effects of climate change. These include, for example, poor education and insufficient financial means, structural, legal and cultural barriers, limited access to health infrastructure or unfavorable housing conditions. Refugees, in particular, are highly vulnerable due to the deprivations they have experienced and as a consequence of the physical and mental stresses and strains related thereto. The health risk of transmitting imported diseases, however, is extremely low, even in cases of close contact.

Options for action: Targeted measures to strengthen health literacy among particularly vulnerable target groups, such as elderly people and persons with a migration background, can combat the climate-induced aggravation of inequality. To this end, multiculturalism in health facilities can be used for multilingual communication and transcultural medicine and care through targeted diversity management (high agreement, medium evidence). In particular, target group-specific prevention, promotion of health and treatment, as well as further development of the living conditions of vulnerable groups, can mitigate any further exacerbation of unequally distributed disease burdens – especially with regard to heat and mental health, according to the "Health (and Climate) in all Policies" approach. Such measures can be enhanced by accompanying and supplementary research.

Counteracting Aggravated Health Inequalities Induced by Climate Change

Development dynamics: 14 percent of the Austrian population are at risk from poverty and marginalization. Large families, lone-parent households, migrants, women of retirement age, the unemployed, unskilled workers and people with low education levels suffer from a significantly increased risk of falling into poverty. Even today, socio-economic inequality is contributing to health imbalances: In Austria, persons with no more than compulsory schooling show a life expectancy 6.2 years shorter than that of university graduates (high agreement, robust evidence).

Relation to climate: These health inequalities are in many ways fueled by climate-related changes (high agreement, medium evidence). Exposed workplace and housing conditions have an additional exacerbating impact (such as, for instance, heavy outdoor work on construction sites or in agriculture, lack of urban green spaces near people's homes, high exposure to noise pollution in living quarters). In the past, heat waves and natural disasters have already affected disadvantaged groups more directly. Add in further vulnerability factors (such as old age), and the situation will deteriorate (high agreement, medium evidence). The heat wave that struck Vienna in 2003, for instance, led to a significant increase in the number of fatalities in low-income districts in particular. As yet, the impacts of climate change on health inequalities have hardly left their mark on "Health in all Policies" approaches. Globally, unequal exposure to health risks induced by climate change has been identified as a key factor. As a consequence, the UN Sustainable Development Goals (SDGs) address the correlation between socio-economic status, health and climate. By contrast, strategic and political discussions in Austria tend to overlook it.

Options for action: Building on the measures of the Austrian Health Target 2 "Fair and Equal Opportunities in Health", in particular with regard to poverty alleviation, the aggravating factors of climate change can be cushioned by way of targeted support measures in the fields of life and work environments. By setting up a coordination and exchange platform mirroring a "community of practice", it is possible to support the hands-on approach when implementing these measures (medium agreement, low evidence). During the implementation of the sustainability goals at public administration, governmental and other societal levels (economy, civil society) in Austria, it is possible to further deepen the coordination of cross-policy cooperation to promote fair and equal opportunities. Interdisciplinary research projects on health-related equal opportunities in the light of climate change play a pivotal role (high agreement, low evidence) and may provide insights as to which targeted measures to take in order to bring back into balance health-related inequalities of particularly disadvantaged groups and very strongly affected regions.

Developing Climate-related Health Literacy for the Purpose of Reducing the Impact of Climate Change

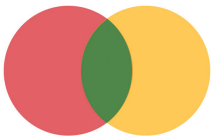
Development dynamics: Acquiring a high level of health literacy enables any individual to better understand physical and mental health issues and to decide wisely in health matters. Low levels of health literacy will lead to low levels of treatment adherence, delayed diagnoses, poor self-management skills and an increased risk of developing chronic diseases. Consequently, poor health literacy results in high health care costs. According to an international survey, more than 50 percent of the Austrian participants have developed only inadequate or problematic health literacy skills. These figures

were as high as 75 percent for people of poor health, with little money or older than 76 years of age. The survey shows that mostly this is not due to the individuals' cognitive skills, but rather to various aspects of the health care system (medium agreement, medium evidence). The health reform entitled *Zielsteuerung Gesundheit* (Target-based Health Governance) and the Austrian Health Targets took note of this predicament and set out operative targets. What they fail to acknowledge, however, is the role climate change plays in terms of people's health.

Relation to climate: Disadvantaged groups fall victim to climate change much more often and, in addition, they often show lower levels of health literacy, while at the same time, the information material available does not reach them quite as readily (high agreement, medium evidence). The action plan of the Austrian adaptation strategy already points to existing education and information projects, especially with regard to health topics. Also, from a climate protection perspective, a healthier diet and health-enhancing physical activity in everyday life can contribute to lowering greenhouse gas emissions.

Options for action: Improving climate-related health literacy may result in a reduction of the impact climate change has on the health of particularly vulnerable groups and even improve people's health. What is required to this end is for all competent health and climate-related authorities both at federal and provincial levels to join forces in intersectoral cooperation (high agreement, medium evidence) following the maxim: the more target group-oriented the measures, the better the effects to be achieved. Thus, it would be of vital importance to systematically teach health care professionals about climate-specific health care issues as part of their education and training, because it is they who can address individual health concerns and give appropriate individualized advice and assistance and who can initiate lifestyle improvements in people's living environments. Key topics of relevance to the climate in this respect are: heat, also in combination with air and noise pollution, allergies, (newly emerging) infectious diseases as well as diet, mobility and local recreation. All this will help to create a widespread dissemination of climate-related health literacy, especially through personal talks and counseling on climate-friendly health behavior (e.g. active mobility and healthy diet). Health professionals, most notably physicians, are called upon to act as "personal health advocates". Measures meant to improve the quality of dialogue in patient care (education and training) can be extended to also include the climate change aspect. By promoting targeted educational measures in schools (curricula and teaching practice), children and adolescents can be taught to adopt a climate- and health-conscious lifestyle.

5 Leveraging Opportunities for Climate and Health



Apart from identifying impending threats, measures can be taken in areas suited to generating benefits for both climate and health. By fine-tuning political instruments, actions beneficial to climate and health can be made more appealing and detrimental actions can be made less worthwhile, which could lead to changes within otherwise problematic areas as well.

5.1 Diets

Need for action: From a health perspective, a dietary change would be in order, with a particular focus on reducing excessive meat consumption for climate and health reasons. In Austria, meat consumption significantly exceeds the healthy levels recommended by the Austrian food pyramid, with amounts for adult males, for example, tripling the recommended levels, while the share of cereals, fruit and vegetables is too low (high agreement, robust evidence). Like many other countries, Austria is experiencing an increase in nutritional diseases. The consumption of animal products significantly increases the risk of developing diabetes mellitus type 2, high blood pressure and cardiovascular diseases. The implementation of the United Nations' Sustainable Development Goals (SDGs) also requires changes in dietary behavior, as their target 2.2 postulates to "end all forms of malnutrition by 2030". In Austria, however, one in every five children below the age of 5 is malnourished (overweight).

Relation to climate: From the climate impact perspective, it is uncontested that vegetable products affect the climate to a much lesser extent than animal products, especially meat, do. Globally, the agricultural sector emits roughly 25 percent of all greenhouse gas. The livestock sector alone generates 18 percent of global GHG emissions. In Austria, the agricultural sector gives rise to roughly 9 percent of the country's GHG emissions (excluding the GHG emissions of net meat imports).

Potential: A scientific review covering more than 60 studies concludes that by fundamentally changing dietary patterns, GHG emissions from agricultural production could be reduced by up to 70 percent. Although comparable only to a limited degree with regard to health impacts, the studies showed that the relative risk of a premature death from nutritional diseases can decrease by up to 20 percent. Despite the lack of methodological standards, it can be summarized that a more plant-based diet can help reduce the number of prema-

ture deaths and the occurrence of nutritional diseases and curb diet-related GHG emissions considerably (high agreement, robust evidence).

Options for action: Potential action may face resistance from the parties involved for different reasons and despite strong evidence, and the biggest challenge will be overcoming this resistance. The best way to go about it would be to develop a participative and coordinated management of measures in order to avoid effects detrimental to farmers and consumers, for instance.

Scientific analyses suggest that "soft measures" such as information campaigns prove ineffective in changing prevailing nutritional trends. By contrast, clear price signals, accompanied by targeted information campaigns as well as advertising bans, can be highly efficient in achieving changes (high agreement, medium evidence). Price hikes for meat products in the wake of raised compulsory standards in livestock farming, for example, are suited to send out a clear message. The amount of money consumers pay for food will remain constant – with the help of support measures where necessary – as consumers will partially renounce the consumption of expensive meat in favor of lower-priced fruits and vegetables, which will re-balance their budgets to some extent. Similarly, farmers' revenues will remain steady as a decrease in supply will result in a rise in prices per kilo. Alternatively, studies suggest taxes on food based on its greenhouse gas impact, with revenues to be used to compensate for income losses, to support prices of wholesome foods worth promoting from a health perspective, and for the purposes of health promotion in general.

It should be noted in this respect that currently the public is obliged to pay for all social and health care costs driven up by unhealthy diets. The German *Umweltbundesamt* (UBA; Federal Environment Agency) advocates the reduction of VAT rates on fruit and vegetables in order to generate benefits for the climate and public health. The Food and Agricultural Organization (FAO) of the United Nations pleads in favor of taxes and charges to reflect the environmental damage inflicted in order to render livestock production more sustainable. Taxes on animal products in the amount of EUR 60 to 120 per ton of CO_2 implemented in each of the EU-27 may help to save between approx. 7 and 14 percent of GHG emissions from the agricultural sector (high agreement, medium evidence).

An additional approach would be to re-think marking obligations: Rather than putting labels on products that are climate-friendly and healthy, it would make more sense to label products for being harmful to health or the climate.

For starters, an important approach would be to serve healthy and climate-friendly food in state institutions such as schools, kindergartens, military barracks, hospitals and retirement homes, and also in hotels and restaurants (high agreement, medium evidence). To add a further leverage point, it would be advisable to reinforce health and climate literacy in the education and training of cooks, dietitians, nutritionists and purchasers for large food and restaurant chains.

State policies should have a vital interest in climate-friendly and healthy dietary behavior, as it does more than just serve to meet climate objectives because it leads to increases in related labor productivity and to cuts in public health spending, and results in an unburdening of public budgets.

5.2 Mobility

Need for action: Transport is a highly relevant sector in terms of climate and health. It accounts for 29 percent of Austria's GHG emissions, 98 percent of which are caused by road transport (44 percent of the latter from freight transport and 56 percent from passenger transport respectively, 2015). Emissions have risen by 60 percent since 1990 (reference year of the Kyoto protocol) with a disproportionate increase in freight transport. Poor air quality in cities and in alpine valleys and basins remains a problem in Austria, especially with regard to nitrogen dioxide emissions – with this in mind, the EU initiated infringement proceedings against Austria in 2016. Particulate emission and ground-level ozone readings are also exceeding their respective limit values (with recordings of elevated ozone levels at 50 percent of all measuring stations). Emissions are mainly caused by road traffic, and, to a great extent, by diesel-powered vehicles (high agreement, robust evidence). 40 percent of the participants in a survey of the Micro-census conducted by Statistics Austria (Federal Austrian Statistical Office) reported that they were annoyed by noise with road traffic as a decreasing but still dominant source. With regard to freight trains, policymakers have already created incentives by way of noise-differentiated track access charges to have providers put into service quieter brakes (which can help reduce noise by up to 10 dB).

Necessary as it may be, the technological transition from fossil fuel vehicles towards electric vehicles alone will not suffice to meet all the different goals as it fails to redress problems such as the risks of accidents, particulate pollution from tire and brake wear as well as resuspension, noise, traffic jams and land use for road infrastructure. It is especially multi-track vehicles which, due to their high space requirement, hamper quality of life improvements in urban areas – when temperatures are rising in particular. In addition, any major positive impact on the climate footprint will only be felt if power generation for electric vehicles goes climate-neutral. The health potential of climate-sensitive mobility does not stop at electric mobility (high agreement, robust evidence). The SDGs (target 3.6) also require the number of road fatalities to be globally halved by 2020, which cannot be realized through electric mobility alone. Statistics, however, indicate that the number of road fatalities in Austria is on the decline and that, by adopting additional measures, a halving of said numbers seems feasible. A reduction in car use, mileages and driving speed, in particular, is likely to reduce road fatalities and noise

pollution, the emission of pollutants and GHGs (high agreement, robust evidence).

Potentials: The shift towards more climate-friendly means of freight and passenger transportation should at any rate become part of the solution. By attracting customers through improved services, it is possible to increase passenger numbers for local public transport and to reduce the modal share of private motorized transport at the same time. Vienna succeeded in reducing its modal share in private motorized transport by 4 percent within less than a decade. A shift towards active mobility (walking, cycling) and public transport will lower pollution and noise emissions and lead to an increase in physical activity, which in turn helps reduce obesity and overweight, minimizes the risk of developing cardiovascular and respiratory diseases and cancer, as well as the risk of sleep or psychic disorders. All these factors taken together lead to an increase in life expectancy with more years of healthy life (high agreement, medium evidence). In addition, the modal shift brings about significant cost savings for public health care. Cost-benefit analyses conducted in Belgium found that the amounts that could be saved in health care were between two and fourteen times higher than what had to be spent on bicycle paths.

A statistical survey of 167 European cities indicates that by extending a bike-path network it is possible to raise the share of bicycle traffic and that, by persistently adapting traffic concepts, it is indeed possible to increase the cycling modal share by more than 20 percent in German (e.g. Münster 38 percent) and Austrian cities (Innsbruck 23 percent and Salzburg 20 percent).

Through scenarios based on tried and tested measures, a study on the cities of Graz, Linz and Vienna indicated that, even excluding electric mobility, deaths per 100,000 population could be reduced by 60 in actual numbers and CO_{2equ} emissions from passenger traffic by 50 percent, whilst curbing annual health care spending by almost EUR 1 million per 100,000 population in the process. This could be achieved through a mix of policies combining the establishment of strolling zones, reduced-traffic zones, the construction of new bike paths and infrastructure, an increase in service frequencies of public transport and cheaper fares in urban/rural transit. Provided power generation goes carbon-neutral and if complemented by electric mobility, all of these measures could save 100 percent of CO_{2equ} emissions and prevent 70 to 80 deaths per 100,000 inhabitants annually (high agreement, robust evidence).

Options for action: Urban mobility in particular offers vast health co-benefits and great potential for improving quality of life, and therefore also is a promising opportunity for climate protection and health improvement. By becoming more people-friendly rather than car-friendly and by embracing active mobility, cities, towns and villages would improve social contacts, well-being and health statuses - and even reduce their crime rates. In addition, the dismantling of roads and parking lots will "depave" the way for creating green areas and for alleviating "heat island" effects in the process. All of these advantages can be taken care of through appropriate measures of settlement structuring, such as physical layouts of homes, workplaces, shopping malls, schools, hospitals or retirement homes, which determines traffic volumes to a large extent, as well as through legal frameworks and guidelines for land use and urban planning (high agreement, robust evidence).

By promoting and incentivizing active mobility and by favoring public transport and sharing models over private motorized transport, it becomes possible to exploit previously untapped potential: active mobility can be promoted by creating low-emission zones of reduced motorized traffic as well as pedestrian promenades and bicycle boulevards, for instance, while, at the same time, parking spaces could be reserved for electric vehicles or approval granted only to car sharing companies committed to electric vehicles. It would eventually be possible to fund and intensify such pull measures through strategies to internalize external costs, in particular those of motorized traffic.

For the mobility sector to be of great benefit to both climate protection and health promotion, the institutional cooperation of all competent municipal, provincial and national authorities is recommended. To be functional, any cooperation first and foremost requires that necessary resources and capacities be made available for the exchange of information and opinions (high agreement, medium evidence).

A lot could also be done with regard to air traffic, which is encouraged and favored by policymakers and which is not covered by the Paris Climate Agreement. Air traffic, undoubtedly, leaves a very large carbon footprint mark and urgently requires action to be taken (high agreement, robust evidence); any plans to reduce it, however, have often been declined due to the various economic interests involved. Air traffic could be reduced by imposing a CO_2 tax on hitherto untaxed jet fuel, for instance, to eventually reduce harmful emissions such as particulate matter, secondary sulfates and nitrates as well as noise and the elevated risk of contracting infectious diseases.

5.3 Housing

Need for action: Housing conditions play an essential role in terms of health, well-being, climate protection and any adaptation to climate change. Both the physical layout (settlement structures) and building techniques trigger long-term path dependencies and have far-reaching implications for mobility and leisure behaviors. Buildings account for roughly 10 percent of Austria's GHG emissions with numbers declining, but the housing stock has been increasing for decades and 87 percent of all buildings are single-family or duplex houses, with apartment buildings containing 3 or more units accounting for a mere 13 percent.

In cities in particular, increasing summer heat loads during the daytime with no significant drops in temperatures overnight lead to uncomfortable indoor air climates and eventual health issues (especially for people in poor health and the elderly as well as children) (high agreement, robust evidence). Other well-documented stress factors include noise and air pollution. Noise levels measured overnight in front of a window which exceed approx. 55 dB(A) can cause health issues such as impaired cardiovascular regulation, mental disorders, reduced cognitive performance or glucose imbalances. Such elevated levels occur regularly on very busy roads (within cities and on highways and expressways) as well as near airports. The option of airing apartments is limited by noise and air pollution as well.

Options for action: To ensure that the focus of urban planning is on health improvement and climate-friendly housing, it would be essential to have climatologists and medical specialists participate in urban planning processes. When it comes to construction and housing policies, climate change adaptation strategies and emissions reduction on the one hand and the traffic situation and green and local recreation areas on the other cannot be addressed separately. While rules and regulations and support measures are increasingly taking account of the effects of climate change, they often fail to acknowledge the close interdependencies between housing and traffic and/or parking spaces.

When it comes to the energy-oriented restoration of old building stock in Austria, rates are as low as 1 percent and the quality of renovation is poor as well. Differences in ownership structures and diverging interests of landlords and tenants are urgent obstacles that need to be overcome. An increase both in the quality (e.g. high-quality thermal insulation, use of comfort ventilation systems) as well as the numbers of premises to be renovated will help reduce heat stress and will produce positive health effects (high agreement, robust evidence), which equally applies to office buildings, hospitals, hotels, schools, etc. This can also help to reduce the need for energy-intensive air conditioning systems. While the call for "affordable housing" may be understandable, it should not, however, translate into "cheap and poor construction design", as poor construction means elevated heating costs, which ultimately affects affordability. In addition, low-emission heating and hot water systems can become key components in terms of climate protection; in densely populated areas, however, they can achieve even more by improving people's health, since they contribute to reducing air pollution (high agreement, robust evidence).

Single-family and duplex houses with their attached garages and road space mean additional sealed surface, materials and energy input, and they imply a long-term commitment to private motorized traffic. As for new buildings, any such constructions should be called into question because of their climate footprint and health implications (high agreement, robust evidence). With a population increase of almost 2 percent and with an increase in sealed areas of 10 percent (approx. 54 acres per day), Austria is at the top of the list in Europe when it comes to soil sealing. As a consequence, rather than aspiring to own a house and garden it would be better to incentivize more attractive solutions such as apartment buildings situated in well-developed, low-traffic areas offering a high quality of life and access to green spaces, which, in addition to the numerous climate and health benefits they entail, help to strengthen feelings of community. What is needed now is the development of suitable passive and energy-plus building standards for larger buildings (high agreement, robust evidence).

5.4 Health Care Sector

Need for action: Accounting for 11 percent of the country's GDP (2016), Austria's public health care system is not only of great importance in economic and political terms as well as for society as a whole, it also has a climate impact; and it is stretched to its financial limits. Ironically, contrary to its true purpose of promoting health, it directly (e.g. through heating/air conditioning and power consumption) and indirectly (mainly through the manufacture of medical products) fuels climate change and its health implications (high agreement, medium evidence). Yet, the question of how to reduce emissions from the public health sector has neither been addressed by Austria's climate and energy strategy nor on an international level. Similarly, the health care reform papers fail to acknowledge its impact on climate change. Although Austria's National Health Targets do refer to sustainably securing the natural resources (Health Target 4), they do not point to the fact that it is essential to reduce emissions from the health care sector. Thus far, some hospitals have implemented efficiency/savings measures to reduce building-related emissions – in part for economic reasons. For the first time, a project within the framework of the Austrian Climate Research Program ACRP is currently gathering data on the Austrian health care sector's share in GHG emissions.

Potential: As for traditional environmental protection, for instance, in building construction, it turns out that GHG emissions are to a large extent caused by intermediate consumption. A carbon footprint study focusing on the US public health sector indicates that 10 percent of the United States' GHG emissions are directly or indirectly attributable to the health care system, with emissions from intermediate consumption exceeding direct on-site emissions, and that the lion's share of GHG emissions stems from the manufacture of pharmaceutical products. Studies in the UK and in Australia paint a similar picture, though indicating slightly lower figures (high agreement, medium evidence).

Avoiding unwarranted or non-evidence-based treatments (and hospitalization) helps not only to reduce emissions (e.g. particulate emissions) from the health care system and their health implications but will also be beneficial in terms of pro-

tecting the climate and health in general (high agreement, medium evidence). This includes avoiding medication over- and under-use, multiple or duplicative diagnoses or incorrect assignments (which is when treatment and care do not fit the diagnosis).

Options for action: For health and climate benefits to come to fruition, it is advisable to prepare a specific mitigation (and adaptation) strategy for the health care sector to provide a political guideline for all authorities involved at federal, provincial and organizational levels. And, with reference to the Austrian Health Target 4, any such strategy should aim to reduce direct and indirect GHG emissions, other harmful emissions, waste, and the use of resources as well as to adopt adaptation measures such as the development of climate-related health literacy and to integrate the topics of "climate and health" into education and training programs of health professionals. The various national and international policies can serve as role models during the implementation process [e.g. U.K. National Health Service, *Österreichische Plattform Gesundheitskompetenz* (ÖPGK; Austrian Platform Health Literacy)]. At the same time, participatory structures which allow for an exchange between the various parties involved should be established and form an integral part of the process.

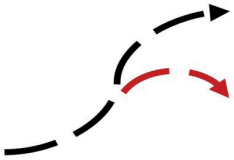
Systematically integrating (if necessary compulsory) eco-quality criteria into quality control and utilizing the incentive mechanisms of the *Gesundheitsqualitätsgesetz* (Health Care Quality Act) can help and support environmental management departments in hospitals in particular.

Significant reductions in GHG emissions, in risks to patient safety and cuts in health care costs could be realized by avoiding unnecessary or non-evidence-based diagnoses and therapies (high agreement, robust evidence). Systematically enforcing the international initiative *"Gemeinsam klug entscheiden"* ("Making Choices Together/Choose wisely") may prove highly promising in curbing medication over, under- and misuse and hold great potential for mitigating economic and ecological impacts (high agreement, low evidence). What is problematic when it comes to avoiding unwarranted diagnoses and therapies is the fact that the pharmaceutical and medical device industries fund medical training programs in Austria with considerable amounts so that programs to a very large extent tend to cater to specific interests.

Consistently prioritizing multi-disciplinary primary care, health promotion and ill-health prevention in accordance with the health care reform can contribute to reducing energy-intensive hospitalizations and, therefore, GHG emissions (high agreement, low evidence). Medical treatments that focus to a greater extent on health promotion can help people adopt healthier diets and increase their physical activities through active mobility – which will also contribute to climate protection. In addition, the handing over of a greater number of patients to regional primary care (registered medical practitioners or health care centers) can reduce GHG emissions, as it reduces the traffic flows of patients and visitors to and from hospitals.

The health care system's impact on the climate will have to be analyzed during these implementation initiatives (e.g. analyses of GHG-intensive medical products and possible alternatives). Given their complex nature, the interdependencies require the conduct of adequately funded research projects on international, interprofessional, inter- and transdisciplinary levels with a focus on practical implications.

6 Transformation at the Intersection between Climate and Health



For the purpose of keeping the health implications of climate change in Austria in check, it will not suffice to enforce technological solutions such as energy efficiency improvements, electric mobility, new therapies or building modernization, nor will such solutions be sufficient to meet the goals set forth in the Paris Climate Agreement, let alone to fulfill Austria's commitment to the SDGs vis-à-vis the world community. Rather, it is necessary to launch a comprehensive transformation process which challenges consumption patterns as well as economic modes of production and our health care system in search for answers in order to set the course for new development strategies that offer appealing qualities of life and equal opportunities for all in accordance with the Sustainable Development Goals (SDGs). Any such comprehensive transformation is bound to face resistance, such as inherent preservation tendencies which often pander to group interests and fail to adequately consider long-term disadvantages and emerging risks for the common good. It is where climate and health issues intersect that new and innovative concepts should be tried out in specific gradual steps of transformation since, in some areas, the health benefits will have a bearing on a great number of people, will set in rather quickly and be accompanied by positive climate effects.

6.1 Initiating a Cross-policy Transformation

Any transformation process will have to be stepwise, reflective and adaptive in nature in order to not run the risk of imposing incoherent individual measures which fizzle out rather ineffectively. All efforts to harness the numerous synergies and

to avoid detrimental reciprocal effects will be in vain unless the interdependencies of, amongst other things, heat events, demographic dynamics, traffic, including active mobility, green areas, healthy diets, climate-related health literacy and a more climate-friendly health care system that focuses on disease prevention and health promotion are jointly considered and developed in the process.

It is true that some of Austria's strategies have already taken account of such a transformation process at the intersection between climate and health, but they hitherto failed to gain any satisfactory momentum. At the very least, the following three strategic areas offer synergies to be tapped into: On the one hand, there are the Austrian Health Targets with their aim at high-impact climate benefits (Target 2: Fair and Equal Opportunities in Health, Target 3: Health Literacy, Target 4: Secure Sustainable Natural Resources such as Air, Water and Soil and Healthy Environments, Target 7: Healthy Diet, Target 8: Healthy and Safe Exercise); and on the other, there are the Paris Climate Agreement as well as the recently adopted Austrian climate and energy strategy together with the Austrian adaptation strategy. The climate and energy strategy places the main focus on traffic and buildings, areas highly relevant to public health. Health promotion through active mobility forms an integral part of traffic concepts. And, not least by virtue of ratifying the UN General Assembly's Resolution "Transforming our world: the 2030 Agenda for Sustainable Development" with its 17 development goals and 169 targets, Austria has committed to far-reaching transformative steps in the fields of climate change and public health. The current report by the Federal Chancellery already takes note of the fact that adhering to the Health Targets will contribute to achieving a variety of sustainability goals.

In its latest status report on the environment and health in Europe, WHO/Europe identifies the lack of intersectoral cooperation at all levels as the main obstacle on the road to the successful implementation of climate measures (high agreement, robust evidence). Likewise, the EU calls for the integration of health into climate change adaptation and mitigation strategies of all sectors for the purpose of public health improvement.

Climate policies, in this regard, can become the driving force behind the "Health in All Policies" approach, and health the engine to propel integral transformative steps. What would be needed to realize this potential, however, is a decisive cooperation that can prove successful in Austria based on the aforementioned groundwork that has been laid (Health Targets, climate and energy strategy, Sustainable Development Goals). If rooted in a precise political mandate, climate and health policies could be tied together where topics intersect through the establishment of exchange structures for a transformation process, which, in turn and in addition, can make key contributions towards achieving the sustainability goals in the process. For the implementation process to be rapidly completed it would be necessary to have the government, the provinces and the municipalities participate on a broad basis, and also to include social insurance agencies and academics. Topics that climate and health strategies should address specifically include the complex around heat-buildings-green areas-traffic, a healthy and climate-friendly diet, active mobility, developing health literacy, the emission mitigation and adaptation strategy for the health care system and also the systematic application of the *Umweltverträglichkeitsprüfung* (environmental impact assessment) in tandem with a health impact assessment for regional and urban planning.

6.2 Harnessing the Scientific Potential for Transformation

Even if there is no dispute as to which goals to set for both health and climate strategies – e.g. the lowering of meat consumption, a reduction in air traffic or an urban density increase – no answer has yet been provided as to how the respective measures can be formulated to win over the public and decision-makers and to avoid disadvantages and make the most of opportunities. This requires innovative scientific methods which not only monitor and analyze the systems from the outside but which, by favoring transdisciplinary approaches, help set in motion a targeted participative transformation and launch learning processes that are more likely to result in actual solutions. In any case, it will also be up to the science community to evaluate measures, identify interconnections vital to the success of strategies or to come up with forms of communication suited to accessing groups which are otherwise hard to reach.

To increasingly guarantee that only sensible and assertive action is taken, it is expedient to develop and implement a concept for monitoring the climate impact on all ecospheres and on health. To further the understanding of the direct and indirect effects of climate change, it stands to reason to establish and operate test regions. And it is also advisable to draw up a comprehensive population register following the example of Scandinavian countries in order to get a firmer grasp on climate vulnerability and the harmful effects of climate change thus far.

In addition, and to further ensure that appropriate action is taken, it will also be necessary to fill the gaps in our knowledge of where the issues of climate change, demographics and health intersect. This includes the collection of data on the emissions from health services (including intermediate consumption), the preparation of mitigation measures, and life-cycle assessments of medical products, in particular drugs, to help evaluate side effects such as the climate impact of medical treatments in relation to the treatment outcome (whether any success of a treatment is worth the damage). There is also a need for analyses of the efficiency of monitoring and early-warning mechanisms that focus on the reduction of harmful effects; in this context, however, some methodological questions of how to quantify treatment success have yet to be

answered (e.g. measurability of a reduction of mental trauma incidents).

Both medical as well as agricultural research would do well to improve transparency with regard to their scientific problem-solving techniques, test and trial designs, and also sources of funding, since research and education in both disciplines are increasingly funded by interest groups and the economy. This could be a necessary step towards an actual reduction in overmedication and multiple or duplicative diagnoses.

With buildings becoming increasingly hi-tech in order to improve energy efficiency, it will be necessary to analyze whether this will cause new health issues and how much net GHG emissions are actually saved as soon as intermediate consumption is factored into the carbon footprint.

With demand for quality food at lively levels, organic farming may help to achieve the Paris Climate Agreement objectives. An assessment, however, would require conclusive scientific data on the health effects of organic vis-à-vis non-organic food.

Ultimately, there is much to be learned from initiatives which have already adopted healthy and climate-friendly lifestyles. Such initiatives include, for instance, ecovillages, slow food or slow city movements and transition towns. Attractive and suitably convenient lifestyles can be incentivized by reducing negative and enforcing positive factors. Multi-faceted transformation research as well as research-oriented teaching could accelerate the respective transformative developments and could, thus, reduce impeding and promote beneficial factors to foster acceptable and viable developments that improve the quality of life.

Synthesis

The chapters of this Synthesis correspond to the chapters of the full text. For more detailed information please refer to the corresponding chapters of the full text. The full text also includes references to online supplements featuring additional texts on selected topics of the Report (see https://www.austriaca.at/8427-0/ [in German]). In addition, the full text also contains boxes on special topics (urban development and demography, air traffic, wind power plants) and a case study, respectively (Steirischer Hitzeschutzplan [Styrian heat protection plan]) that are not included in this Synthesis Report.

Contents

Chapter 1: Preliminary Note

1.1 Challenges

On a global scale, the health effects of climate change are already being felt today, and based on current projections of the future climate, the world population is likely to be faced with a high health risk (IPCC, 2014: Smith et al., 2014; Watts et al., 2015; Watts et al., 2017).

In Austria, the effects of climate change are to be considered a significant and growing threat to health. The Report assesses three different pathways:

- Direct effects of climate change on health caused by extreme weather events, like, for instance, more frequent and more intense heat episodes, flood events, heavy precipitation or drought.
- Indirect effects of climatic and weather phenomena affecting, among other things, pathogens and vectors of infectious diseases, thus increasing the probability of the occurrence of certain infectious diseases (APCC, 2014; Haas et al., 2015; Hutter et al., 2017).
- And ultimately, through trade and travel, climate-induced changes in other countries may also have a bearing on public health in Austria (Butler & Harley, 2010; McMichael, 2013).

Following the Austrian Assessment Report (*Österreichischer Sachstandsbericht Klimawandel 2014*) AAR14 (APCC, 2014), this first Austrian Special Report (ASR) of the Austrian Panel on Climate Change (APCC) presents a comprehensive synopsis and assessment of scientific documents on the specific topic of "Health, demography and climate change". The assessment aims to explore where it is possible to draw on verified knowledge, where there is consensus and where dissent, where there are still great uncertainties and where it is advisable to continue observing developments. In doing so, it is not only about recognizing imminent threats, but also about identifying opportunities. Strategies coordinated between climate policymakers and health policymakers may help reduce greenhouse gas emissions as well as generate health benefits. Following the style of the AAR14 and the IPCC Reports, a transparent process, comprehensive in terms of content and taking account of an interdisciplinary balance was implemented in order to provide a reliable assessment that is relevant to Austria and justified by the process and that provides a basis for decision-making in the fields of science, administration and politics, facilitating efficient and responsible action. The key finding of this work of one and a half years is that a well-coordinated climate and health policy can be a powerful stimulus for transformation toward a climate-compatible society that promises a high level of acceptance owing to its potential to bring about better health and a higher quality of life.

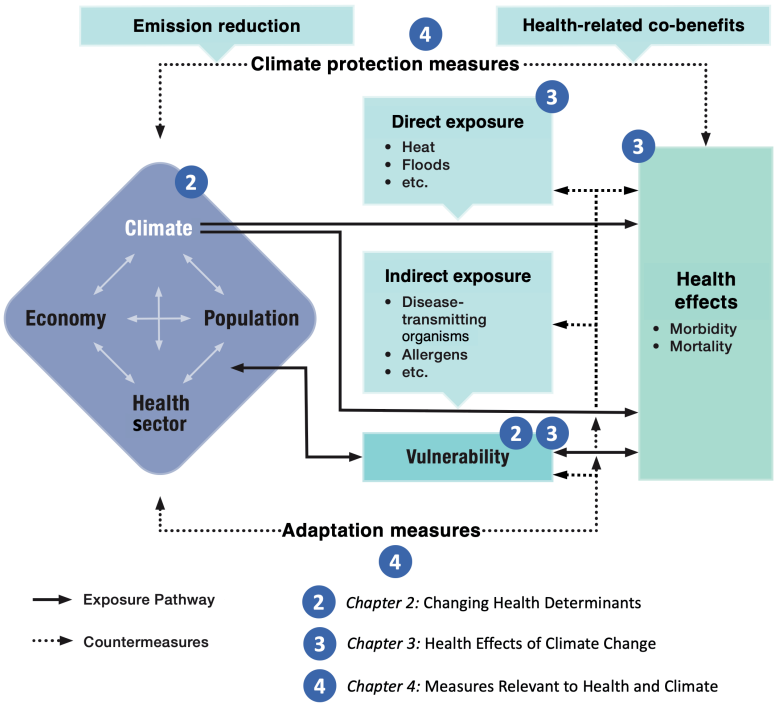


Fig. 1.1: Dynamic model of the determinants dealt with in the Special Report and their health effects: Through pathways, changes in the four health determinants climate, population, economy and the health sector cause health effects, while countermeasures are taken in the form of adaptation and climate protection measures. Those changes can have direct or indirect health effects. People's changing vulnerability to the effects is also a significant factor. Health effects are measured by morbidity and mortality rates. Notes: In scientific literature, organisms that transmit diseases are often referred to as disease transmitters or vectors. The numbers in the figure refer to the respective chapters of the Special Report. Chapter 1 Preliminary Note and Chapter 5 Conclusions are not indicated in the figure.

1.2 Structure

This Synthesis summarizes the key statements of the individual chapters of the ASR18. Details on the five chapters can be looked up in this comprehensive Assessment Report.

The Report's main focus is on climate change in conjunction with changes in the fields of population, economy and the health sector. There are interdependencies between these determinants of health, as a change in climate and changed demographic characteristics have, for instance, an impact on the economy and the health care system (see Chapter 2). Based on the changes in the health determinants, Chapter 3 focuses on the health effects, taking the changed vulnerability of the population into account. In doing so, the consequences and climate effects in other regions of the world are assessed that affect health via direct and indirect exposure and are relevant to public health in Austria. Subsequently, adaptation measures and climate protection measures are discussed and evaluated in Chapter 4. Particular attention is given to measures that can create co-benefits, i.e. benefits for the climate and for health. Chapter 5 provides a synopsis, draws conclusions and highlights options for action against the backdrop of all uncertainties and/or discusses steps towards an adaptive system development and transformation (see Fig. 1.1).

1.3 Targets and Target Groups

The state of knowledge and its assessment are to illustrate the need for action and show the options for action that are already noticeable in the literature and/or in the discourse among experts. Rather than being policy prescriptive vis-à-vis decision-makers in the fields of politics and administration, this Report is designed to be a resource of policy relevance that is to provide orientation but also stimuli. Accordingly, this Report provides a legitimate basis to decision-makers encouraging them to take steps towards implementation.

Regarding the subject matter, the Report aims to support the fields of climate policy and climate research in acknowledging and using health as a powerful driver in a targeted manner. While it is impossible to predict the mitigated effects of specific climate protection initiatives in terms of severity, frequency and geography, their potential health benefits are well-assessable and they set in locally and fairly quickly. Thus, they justify resolute political action (Ganten et al., 2010; Haines, 2017; Haines et al., 2009; IAMP, 2010). The potential reduction of health effects is another justified and evidence-based argument for taking climate change adaptation measures (Steininger et al., 2015).

In the interaction of climate change and health, demographic dynamics should also be factored in to a greater extent than ever. The Report aims to ensure that climate change and its effects are routinely included as serious factors in the fields of health policy and health research. In addition, the health care system's contribution to climate-relevant emissions, which eventually pose a health risk, is quite significant and should therefore play an important role in health research and health policy.

In this context, target-group specific communication is of vital importance. New opportunities will arise when health becomes an integral part of climate communication. While statements on climate topics tend to either come across as moral appeals to the individual or as cumbersome because they challenge complex structural framework conditions, health-related statements most often point out individual health benefits, with structural factors being largely disregarded. These complementary advantages and disadvantages can be integrated in dialogue-oriented communication.

Finally, the Report hopes to encourage intersectoral cooperation between politics, administration and research in the fields of health and climate, taking demographic dynamics into account. In this context, health co-benefits of climate protection measures and/or of adaptation to climate change in particular provide numerous opportunities for a promising cooperation for the benefit of health and climate.

Chapter 2: Changing Health Determinants

Key Messages

Driven by the rise in temperatures, which progresses at an unprecedented pace, climatic conditions directly and indirectly co-determining the health factors are changing all across the globe – and also in Austria.

- Health-relevant climate indicators are expected to change considerably in the following areas:
  - extreme weather events, their frequency, duration and intensity (e. g. heat waves, drought, heavy precipitation, floods)
  - climate-induced changes in propagation areas of allergenic plants and disease-transmitting organisms (e. g. *Anopheles* mosquitoes) that were previously unknown or uncommon in that region
  - climate-related increased effect of air pollutants
- In order to enhance society's resilience to the expected climate effects, it is necessary to study possible relevant system interdependencies and resulting adaptation strategies.

The population structure also plays a pivotal role in the analysis of the effects of climate change on health.
There are different levels of vulnerability among certain population groups; this vulnerability may be caused by a number of reasons: Particularly vulnerable groups include elderly people, children, people with disabilities, chronically ill persons, minorities and persons with low income who often have only limited access to health infrastructure due to structural, legal and cultural barriers.

As a consequence of progressing demographic aging, an increasing proportion of Austria's population is expected to fall into this risk group. While in 2017 the number of persons aged 65 and older was 1.63 million, this number will rise by half a million (31 %) to reach 2.13 million by 2030.

The vulnerability effects caused by migration, which may be considered another important impact of climatic changes on populations, are less obvious. Whilst migration primarily takes place within national borders, more and more studies suggest that environmental factors are a root cause for international migration. Consequently, the share of this risk group among people immigrating to Austria is expected to go up.

The indirect impact of climatic changes on migration tendencies by fuelling conflicts, which undoubtedly leads to an increase in vulnerability, must not be neglected either. At the same time, however, migration also contributes to mitigating the effect of aging which tends to alleviate vulnerability.

In order to minimize the future effects of climate change on vulnerable population groups, preventive measures are to be taken in due time that cater to the specific vulnerability patterns of different population groups. Neglecting demographic factors may lead to misdirected political measures.

Additionally, economic problems may compromise the provision of public health care services, leading to increased vulnerability.
The most prominent factors include growing inequality, aging or automation in production. Climate change may be one cause of economic changes, but at the same time it can exacerbate the vulnerability to these economic changes.

A sustainable economic framework will be necessary to avoid economic crises that fuel inequality and to ensure successful adaptation to climate change for all.

Climate change affects the health care system and/or the provision of health care, with the competencies to avoid or mitigate its direct and indirect health effects being fragmented and often outside the remit of the health care system.
In response to the increased strain on the health care system in the wake of climate change, it is necessary to extend the range of action beyond the health care system's stakeholders.

Not only do the increased provision and utilization of health care services have implications on health economics, but they also contribute to climate change by generating increased emissions themselves (e. g. through heating/air conditioning, procurement and transportation, etc.).

There are hardly any economic assessments available on the costs and benefits of specific measures for the protection of health against the effects of climate change. It is uncontested that the increased disease burden leads to consequential costs, due to increased prevention costs and the utilization of services, loss of productivity (sick leave), direct losses and the amount of investments, among others.

2.1 Introduction

Pursuant to the conceptual framework for action on the social determinants of health published by the World Health Organization (WHO, 2010a), this chapter deals with the social, political and ecological contexts affecting health, in particular population dynamics, economy and the health care system with special emphasis on changes in vulnerability. The starting point, however, is climate change once again, the direct and indirect health effects of which have to be considered in the context of the complex interplay of the three determinants mentioned above.

Not only do changes in the climate, the economy and health care system have an impact on public health, but also changes within the population itself alter its levels of vulnerability. In Austria, an increased life expectancy and a downward trend in fertility rates have led to an aging population over the past few decades. This changing age structure has repercussions on social security systems, like the health care system, through the reduced proportion of the gainfully employed population, which is expressed in the pension system and the increased demand for long-term care (Hsu et al., 2015). Similarly, migration (not just regarding the population number, but also regarding its composition) also contributes to demographic change (Philipov & Schuster, 2010). Ultimately, these demographic changes influence morbidity patterns as they have an impact on the percentage of vulnerable people. This means that population dynamics have to be considered a key health determinant.

Even though not explicitly mentioned in the original conceptual framework for health determinants, climate change obviously also has an impact on determinants like the economy, the health care system and population dynamics (IPCC, 2014). Health institutions can suffer direct damage, but also indirect damage may occur, e. g. due to the re-occurrence of or repeated increase in certain infectious diseases, making timely risk management and preparation measures in the public health care system necessary to keep up with the new requirements. The public health care system needs to respond to these new challenges and take both the possibilities of emission reduction and timely adaptation as well as possible co-benefits into account (Frumkin et al., 2008; Haines, 2017). Not only would reducing greenhouse gases (GHG) help keep climate change at bay, but also create health benefits as climate-related risks would be minimized.

As far as the effects of climate change on population dynamics are concerned, there is growing evidence that extreme weather events and a deterioration of air quality will be accompanied by significantly higher mortality rates (Forzieri et al., 2017; Silva et al., 2013). Furthermore, the severe consequences of climate change have an amplifying effect on short-distance migration, but an alleviating effect on long-distance migration, because the resources needed for emigration are simply not there due to income losses. In addition, climate change adds to the economic, political and social push factors in the regions of origin (Black, Adger et al., 2011). The changes in the distribution and structure of Austria's population caused by migration, in turn, have repercussions on the population exposed to climate change. In fact, the health risks ensuing from climate change are not evenly distributed across all population groups, and when it comes to vulnerability, demographic differences need to be considered as well (Muttarak et al., 2016).

2.2 Evolution of Health-relevant Climate Phenomena: Climate in the Past and Projections for the Future

The interrelations between climate change and health are manifold and, to some extent, quite complex. Climate has always been extremely important for the evolution of the human species; the slight temperature fluctuations during the Holocene, for instance, laid the ground for the evolution of mankind from the Stone Age up to today's advanced civilizations. The current climate development is different from climate changes in the past; on the one hand, this development is anthropogenic, and on the other, it progresses at a significantly faster pace than it ever did during the Holocene period.

Some meteorological phenomena are particularly relevant to human health (Table 2.1). The severity of the changes and the uncertainty of the statements were assessed by climate experts. In accordance with international literature, the biggest changes are expected in conditions of heat and drought, with the uncertainty of the statement being low. Those changes are associated with a less pronounced drop in overnight temperatures. The time shift in the occurrence of allergies is also considered highly relevant, with the statement being certain. A high number of extreme hydrological events are rated slightly lower both in terms of their severity and certainty of the statement. Interestingly enough, the certainty of the statement and the severity of the change are highly concurrent in the low-value range. This could mean that not enough research work has been done in this field yet to substantiate the statements and therefore, surprises cannot be totally excluded.

Climate-induced phenomena	Indicators with potentially negative effects on health	Possible health effects	Severity of the change
Longer-lasting events	Increase in hot days	Heat stress	2
	Steady rise in temperature during the summer half-year	Thermal stress	3
	Prolonged heat period	Accumulated heat stress	2
	Less pronounced drop in overnight temperatures	No recovery phase	2
	Heat in combination with high humidity	Thermal stress	2
	Sudden changes in temperature	Thermal stress	1
Cold	Increasing number in cold days	Frostbite, strain on the immune system	-1
	Prolonged cold period	Accumulated cold stress	-1
	Decrease in average temperature	Strain on the immune system	-1
Hydrological events	Increased drought	Indirect effect through water and food shortage	3
	More intense and/or more frequent small-scale heavy precipitation	Accidents, injuries, trauma	2
	More frequent and/or more intense flood events	Accidents, injuries, trauma; drinking water supply	1
	More frequent and/or heavier thunderstorms	Lightning strikes; accidents	2
	More events involving huge snow masses	Accidents, injuries, basic supply	1
	More frequent icing events	Accidents, injuries	0
Wind events	More frequent and more extreme storms	Accidents, injuries	0
	More frequent and more extreme cyclones	Accidents, injuries	1
	More frequent and more extreme tornadoes	Accidents, injuries	1
Longer-lasting events	Increasing number of days with particulate matter exceeding the limit value	Permanent stress on the respiratory tract and the cardiovascular system	-1
	Increasing number of days with ozone exceeding the limit value	Stress on the respiratory tract and the cardiovascular system	1
	More fog-prone areas	Accidents	1
Mass movements	More frequent mudslides	Physical impact	2
	More frequent landslides	Physical impact	2
	More frequent rockslides	Physical impact	1
	More frequent avalanches	Physical impact	1
Disease vectors	Increasing number and spread of ticks	TBE, Lyme disease	1
	Increasing number and spread of rodents	Leptospirosis, HFRS, tularemia	1
	Increasing number and spread *Anopheles* mosquitoes	Malaria	2
	Increasing number and spread of *Aedes* mosquitoes	Dengue fever, yellow fever, Chikungunya fever	2
	Increasing number and spread of sand flies	Leishmaniosis	2
	Increasing number and spread of *Culex* mosquitoes	West Nile fever	2
Pollen	Prolongation of the season	Allergies	2
	Seasonal shift	Allergies	2
	Increased occurrence of allergenic plants	Allergies	1
	Migration of allergenic neobiota	Allergies	2
Aquatic systems	Increased water demand	Water shortage	2
	Less snow in lower regions	Water shortage due to increased winter run-off	2
	Less accumulation of ground water	Water shortage	1
	Increase in pathogens in freshwater	Giardia lamblia, E. coli, vibriosis and Cryptosporidium infections	1
Food	Food-borne diseases	Campylobacter, salmonella, E. coli and vibriosis infections; mycotoxins	1
	Crop losses and failure	Food shortage	1
	Increased use of pesticides due to increased occurrence of vermin	Residues from pesticides in food, impact on consumers	2

Increasing certainty of statement → | Overall range of effects | Inverse effect -1 | No effect 0 | Increasing effect → 1 2 3

Table 2.1: Climate-induced and health-relevant phenomena, associated meteorological indicators and corresponding potential health effects as well as climate experts' assessment of the severity of the change and uncertainty of the statement.

2.3 Changes in Demographic Dynamics and Structure

The demographic transformation processes to be expected in Austria in the decades to come are, for the most part, already inherent in the current population structure and can be predicted quite readily. There is, of course, greater uncertainty as to the extent of future migration, which depends both on the push factors in the countries of origin and the pull factors in the countries of destination. It is equally hard to predict to what extent political and climatic instability will increase in the countries of origin in the future and what kind of immigration policy will be pursued, something that depends on the respective political circumstances in the countries of destination. In future, Austria might have to compete with other aging societies for ever scarcer human resources who would have to be "imported" to a certain extent. In the course of increasing automation, however, the demand for human workers may just as well drop (Acemoglu & Restrepo, 2018).

Another uncertainty factor regarding population is attributable to its geographical distribution. Though it is generally expected that the process of urbanization in the industrialized countries will progress even further there is uncertainty about its extent and the resulting socio-economic, health and climate-relevant consequences.

2.4 Changes in the Economy

The current development of the economic situation toward a higher concentration of capital puts an increasing number of population groups at a socio-economic disadvantage. These groups are particularly vulnerable to climate-induced health risks. While mainstream economic sciences principally consider growth as something positive because it ideally leads to more prosperity for all, the environmentally damaging consequences of growth are often ignored. Various non-neoclassical schools of thought, like, for instance, political economics, ecological economics or heterodox economics criticize this fact, arguing that merely calling for higher growth was too short-sighted. Instead, they call for an overall public discourse about how societies should develop in a sustainable way. Within the scope of the initiative "Growth in Transition" ("*Wachstum im Wandel*"), supported by Federal Ministries, federal provinces, universities and NGOs, these issues are extensively discussed on a regular basis.

Socio-economically disadvantaged groups and especially poverty-prone persons are highly vulnerable to climate change as they do not have the necessary resources to protect themselves against its negative effects or because they are particularly exposed due to their living or housing situation. People at risk of poverty include, at an overproportionally high percentage, the unemployed, women, elderly people, children in lone-parent households or in multi-person households with at least three children, and persons with a migration background (Lamei et al., 2013). Thus, implementing distribution policy concepts and reintegrating people into working life will become even more important as climate change progresses.

Climate change can lead to increased direct damage to public infrastructure and to production facilities caused by storms, heavy precipitation, hail, floods or landslides. Moreover, higher temperatures reduce labor productivity and thus also economic output (Dell et al. 2009; Kjellstrom, Kovats et al., 2009).

2.5 Changes in the Health Care Systems

There is broad agreement that climate-induced effects lead to an increased demand for health care services and consequently to higher costs. Health economic studies are usually based on different future scenarios, which means they are subject to certain ranges of fluctuation. Therefore, the extent to which the manifold climate-induced direct and indirect effects will ultimately affect the health care systems is uncertain and highly dependent on (geo)political factors.

2.6 Overview of the Changes in Health Determinants

Although there have been fluctuations in the median temperature profile in the history of mankind time and again, they have never before occurred within such a short period of time as they did since the Industrial Revolution. Even if many people consider the intended climate target of an increase of "a mere" 2 °C over several decades acceptable or even welcome it, the consequences of the climatic changes associated with this increase cannot be clearly determined yet.

There is an extremely high probability that there will be an increase in extreme weather events, and this also applies to Austria (APCC, 2014). The consequences of climate change can vary strongly from region to region and may be different in rural areas and in densely populated urban areas. At the same time, those climatic changes unleash adaptation processes in the biosphere, accompanied by an increased occurrence of allergens but also by changes in the geographical as well as seasonal spread of pathogens.

In parallel to this climate scenario, societal transformation processes are taking place, with their health effects interacting with climate change. Like in almost every advanced industrial

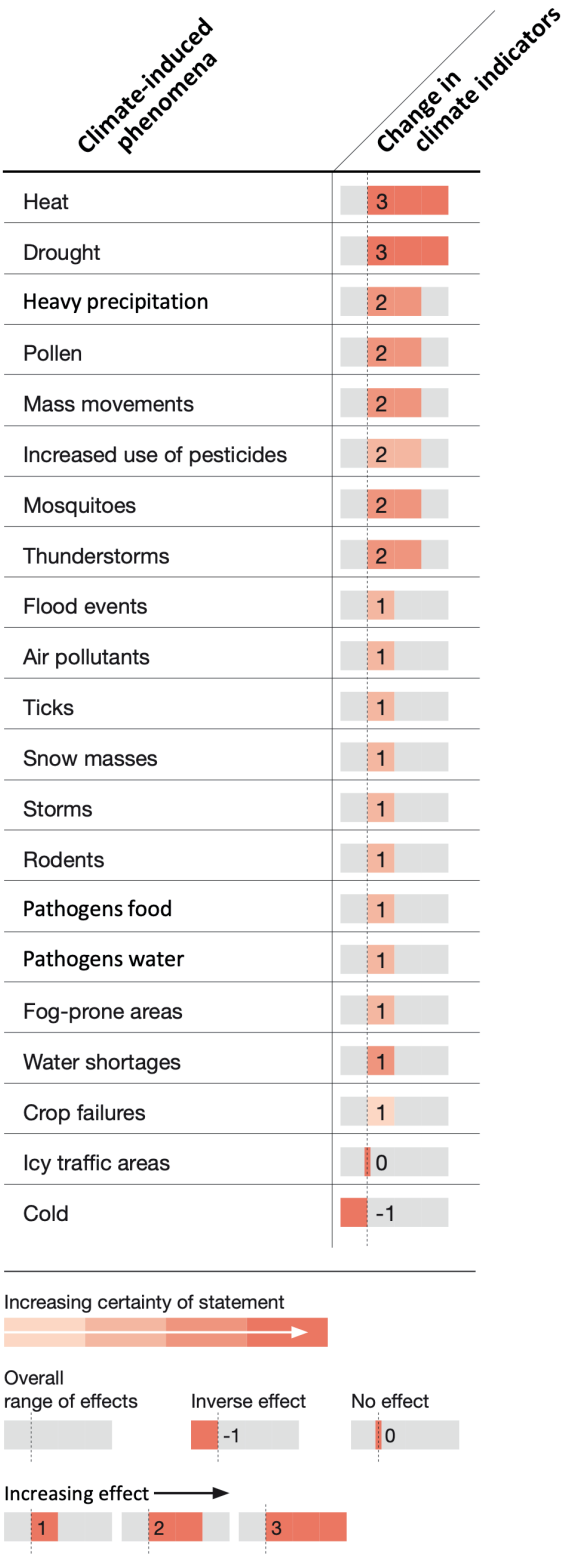


Table 2.2: Change in climate indicators broken down by climate-induced and health-relevant phenomena: 3 indicates a change with highly adverse health effects, -1 indicates a development that is beneficial to health. Uncertainty: Dark red represents high uncertainty, white low uncertainty.

nation, a demographic change that gradually leads to an aging population is also observed in Austria. As elderly persons tend to be more vulnerable, they run a higher risk of suffering health effects caused by climate change. On a global scale, the population is expected to continue growing, contributing to accelerated climate change; at the same time, however, an increase in global migration flows to more moderate temperature zones is to be expected, in particular from regions strongly affected by climate change.

Against the backdrop of economic changes, which have a strong impact on the production processes and the global exchange of commodities, climate change has the potential to aggravate existing inequalities and create new ones. People at the lower end of the income ranking are more vulnerable both at global and national levels, with this vulnerability being exacerbated even further by climate change. They will have to bear the brunt of the economic losses resulting from reduced economic growth rates. As a countermeasure to this development the framework for global business needs to be designed in a sustainable manner.

Chapter 3: Health Effects of Climate Change

Key Messages

The increase in extreme weather events, including heat in particular, represents one of the major implications of climate change in Austria that cause direct health effects. In addition to acute, short-term impacts of extreme temperatures, an even moderate increase in temperatures will lead to a higher mortality rate. The overall mortality rate is still higher in the winter half-year – something to which other seasonal factors (e. g. influenza) contribute as well. The positive effects of climate change in terms of a decline in cold-related deaths, however, will not offset the adverse effects caused by more frequent heat waves. And what is more, there is a risk that changes in the Arctic and the Gulf Stream might bring on longer and colder winters, involving a higher number of cold-related deaths also in Austria. In the medium and long term, people can adapt to temperature shifts, although there are physiological limits to the ability to adapt to extreme temperatures.

High ambient temperatures, particularly in combination with high humidity, are associated with considerable health risks. Future prevention measures – in particular during heat waves – should focus on particularly vulnerable groups (elderly people, children, patients suffering from cardiovascular and mental diseases as well as persons with reduced mobility).

Other extreme weather events associated with climate cause less physical harm in terms of numbers.

However, an increase in psychological trauma mainly because of damage to property as a result of extreme events is to be expected. As no studies have been done in Austria on this issue yet, there is a need for research on the long-term psychological consequences of climate change.

In 2010, air pollutants ranked ninth among the global causes for disease-adjusted life years. In Austria, 40,000 to 65,000 healthy life years were lost due to air pollutants in 2012. Climate protection measures can have direct positive effects on air quality if this fact is taken into account in the planning of these measures.

Through warming and changed precipitation patterns, climate change encourages the colonization of various arthropods such as ticks or mosquitoes and/or leads to a geographic extension of their habitats. A number of arthropods can act as disease-transmitting organisms, so-called vectors. For this to happen, the diseases must either be already endemic or introduced through global trade and travel as well as settle in host organisms, i.e. humans or other endotherms. Monitoring of diseases and of vector populations and potential pathogen reservoirs reduces the risk of major epidemic outbreaks.

The effects of climate change in combination with other factors will add to migration pressure; something the health care system (providing medical care and assistance to arriving migrants and functioning surveillance to prevent the spread of new and old infectious diseases) will have to be prepared for. Data from intensified surveillance from 2015 and 2016 has shown no significant increase in infectious diseases among Austria's native population. Irrespective of migration, there is a high volume of passenger traffic owing to tourism, trade, etc., which is why the Austrian health services have to be ready to cope with previously unknown infectious diseases or changing resistance patterns any time.

3.1 Introduction

Climate change can pose a risk to health via causal chains that are based on primary, secondary or tertiary effects (Butler & Harley, 2010; McMichael, 2013). So-called primary or direct effects describe immediate health impacts of weather phenomena, such as "extreme" weather events like heat or cold, storm or heavy precipitation. So-called indirect or secondary effects refer to health consequences due to changes in various (natural) systems which, in turn, are (also) affected by climate change. These comprise ecosystems where e. g. animals or plants increasingly produce or release allergens or act as vectors of diseases. Indirect effects also include impacts on agriculture (e. g. through drought or heavy precipitation) and possible associated effects on our food, which may result in health problems. Another example would be atmospheric

chemistry which, depending on temperature and solar radiation, has an influence on the health-related effect of air pollutants such as ozone or particulate matter. Climatic changes also have a direct impact on the propagation and survival of pathogens in the environment, consequently generating health effects. Tertiary effects refer to climate-induced changes in other regions of the world, affecting health in Austria by way of trade and travel.

3.2 Direct Effects

Irrespective of climate change, direct effects of extreme weather events are a threat to public health in Austria. In this context, heat waves are the most significant events. Their frequency and intensity will increase further as climate change progresses. At present, Austria records several hundred deaths as a consequence of heat and heat waves each year (Hutter et al., 2007). The rising number of elderly citizens also increases the population's vulnerability. In turn, a certain degree of adaptation is already observed, which becomes apparent in a shift in the "optimum temperature", i.e. the daily mean temperature with the lowest mortality rate.

The connection between extreme weather events and extreme temperatures and an increase in mortality and the risk of disease has been proven worldwide by comprehensive studies and is also documented by Austrian data (Haas et al., 2015). Some uncertainty in the forecast is based on two sorts of considerations: On the one hand, climatological predictions regarding frequency and intensity of extreme events are more uncertain than those regarding mean values, especially when referring to small-scale phenomena, which are of particular importance in the small-scale structured alpine region. On the other hand, both the aging population and the ongoing process of adaptation to gradually changing environmental conditions are the reasons why it is not possible to extrapolate historical dose-response-relations, like, for instance, on the relationship between temperatures and mortality risk. Adaptation to climate change takes place at various levels (e. g. physiological reactions, selection of less susceptible persons, adaptation in individual behavior, in societal rules and in infrastructure) and at different paces. Thus, only rough estimates can be made as to from what point in time the pace of climate change will exceed the limits of the ability to adjust (Wang et al., 2018).

The number of deaths attributable to other extreme weather events such as heavy precipitation with subsequent flooding and mudslides, thunderstorms and storms, is and will not be as high today and in the near future as the number of deaths caused by heat (Kreft et al., 2016). The effects of these extreme weather events, however, range from physical damage to property to existential threat. The long-term psychological effects of repeated material losses were subject to studies in other countries and may well be applicable to Austria. For lack of own studies, which would be much-needed, these effects are not quantifiable for Austria.

3.3 Indirect Effects

Amongst indirect effects it is particularly infectious diseases that attract most media attention. The developmental cycle of infectious agents is strongly influenced by temperatures. This holds particularly true for those pathogens that are transmitted to humans through water or food. Some arthropods, e. g. certain insects and arachnids, are important vectors of diseases. Their occurrence in the course of the year and their geographical spread (e. g. sea level) strongly depend on the temperature. The vectors themselves, however, become a problem only when the pathogens, too, become endemic. Over the past few years, for example, there has already been evidence of sand flies and *Dermacentor* ticks in Central Europe which used to be indigenous only in the Mediterranean region and which transmit life-threatening pathogens such as Leishmania parasites or Rickettsia. It is necessary to conduct continuous monitoring (of the vectors and diseases, for instance, through serological analyses in humans and also in animal hosts if necessary) as well as to provide regular training programs to physicians.

At present, air pollutants create a bigger burden on health (Fitzmaurice et al., 2017; Gakidou et al., 2017), with the contribution of climate change still being uncertain. Hot summer conditions, for instance, contribute to the increased formation of ozone and secondary particles. On the other hand, winter temperature inversions in inner-alpine regions prevent air exchange and thus increase the concentration of pollutants formed locally. Via various mechanisms, both primary and secondary air pollutants produce inflammatory changes – primarily in the respiratory system, secondarily also throughout the entire organism – as well as vegetative responses, oxidative stress and cell damage. This means that air pollutants may have harmful effects on almost all organ systems, with short-term pollution episodes primarily affecting ill persons or people with pre-existing conditions. Climate change will alter the distribution and conversion of air pollutants, but air quality is predominantly determined by harmful primary emissions. In this context, it is essential to keep in mind that climate protection measures may also have beneficial effects at local level where they reduce air pollutant emissions. In Chapter 4 under "Co-benefits", this matter is dealt with in greater detail.

Another example of indirect effects would be the climate's impact on vegetation, with the emergence of new allergenic pollen and the spatial and temporal distribution of allergenic species being most relevant to human health. Drought stress as well as carbon dioxide fertilization may possibly add to elevated adverse health effects (from increased expression of plant aller-

gens). Currently, approximately 25 percent of all Austrians suffer from allergies (Statistik Austria, 2015). Some of these persons are severely affected as there is no highly effective causal therapy for resultant diseases (in particular hay-fever and asthma), and allergen avoidance is not a realistic option.

3.4 Climate Effects in other World Regions Relevant to Health in Austria

Although the population living in the Alpine region will be less affected by climate change as compared to other world regions, Austria will still be faced with climate effects occurring in other world regions through economic, social and political processes. Even problems occurring in more remote regions of the world have a bearing on Austria in the face of the interconnectedness of the global economy. Therefore, climate change will – in combination with global changes – pose new and major challenges to the Austrian health care system.

In terms of movement of goods, poorer quality of imported food (e. g. higher levels of aflatoxin contamination in the event of increased precipitation in the crop-growing regions), for example, is one of the most relevant issues. Regarding the movement of persons, migration and refugee flows (also including so-called "climate refugees" and victims of "climate wars") (Bonnie & Tyler, 2009; UNHCR, 2018; Williams, 2008) attracted quite a bit of media attention in the past few years. These recent refugee flows led to an increase in the number of applications for asylum or of immigrants in Austria, posing new challenges to Austria's health care system. According to recent data not necessarily referring to climate refugees but very well applicable to them as well, there is no relevant risk of infection to the native population. In fact, the care for and health of the migrants should rather be the center of attention. In this context, infectious diseases and the corresponding therapies and preventive measures (vaccination status) are to be taken into account. However, it is probably more important to attend to the psychological traumas triggered by the causes of flight on the one hand, and by experiences during flight on the other.

Although the migration flows of the recent past are not or only marginally a consequence of climate change, they give us an idea of what is to come if climate change continues to progress unchecked on a global scale (Bowles et al., 2015; Butler, 2016). It is most likely that these climate effects in other world regions in this "complex pattern of overlapping stressors" (Werz & Hoffman, 2013) will represent the biggest challenge for the health care system and also for politics in general. The detailed consequences, however, are not predictable, as too many factors are involved that play an important role but cannot be sufficiently controlled or assessed. Thus, the concrete manifestations will mainly depend on the political decisions made at various levels and in various regions of the world.

In a worst-case scenario, climate change in combination with mismanagement and political incapacity may destabilize health care systems and governments of somewhat fragile nations (Grecequet et al., 2017; Schütte et al., 2018). This may first lead to regional health problems. In the case of infectious diseases, in particular infections where there are no preventive measures (vaccinations) or treatments (e. g. antibiotic resistances, partly caused by insufficient therapy) available, these diseases may develop into worldwide pandemics which would also pose major challenges to the Austrian health care system. Global disease surveillance coordinated by WHO and international solidarity are important pillars of preventive health policy.

3.5 Health Effects of Demographic Developments

The proportion of children and adolescents (< 20 years of age) in Austria's population has decreased, while the share of population beyond working age (> 65 years of age) is on the rise. Since 2001, a decline in the prime working age population (20–64 years) has been prevented by migration. It has to be expected that in 2050 27 percent of the population will be older than 65 years of age (see Chapter 2.3.2). The reasons for these changes are a drop in the birth rate and at the same time an increase in life expectancy.

This demographic change is a challenge to pension security models, health care systems and care systems already today, and will be even more so in future. Public expenditure on long-term inpatient care in Austria climbed by as much as 4.7 percent between 2005 and 2015, and amounted to 1.2 percent of GDP in 2013 (OECD, 2015).

The health care sector is faced with a demographic challenge on two accounts. It has to adapt to the increasing and changing demand due to aging; at the same time, the supply of health care professionals is dwindling because of this very aging process. This means that, if the health care system's basic structures remain the same, it will only be possible to sustain its capacities with the help of immigrants in the long term.

Chapter 4: Measures Relevant to Health and Climate

Key Messages

Establishing structural links between health policy and climate policy is an important precondition for protecting the population against the adverse effects of climate change and a contribution to the implementation of the Austrian Health Targets (Gesundheitsziele Österreich) and the Sustainable Development Goals (SDGs). The consequences of climate change are hardly taken into account in Austria's health policy. In principle, the Austrian Health Targets provide a suitable framework for responding to the political challenges Austria is facing due to climatic and demographic changes. The recommendations for action laid down in the Austrian climate adaptation strategy and the strategies of the federal provinces published so far include manifold references to health. In addition to structural and infrastructural measures, they predominantly address the expansion of monitoring and early-warning systems and the implementation of action plans, particularly as a response to the increasing number of extreme weather events like, for instance, heat waves.

The health care sector is an energy-intensive, socio-economically significant and growing sector, and integrating it in climate strategies benefits both public health and the climate. Despite its significance for all aspects of society and its relevance to climate, the health sector has not been a part of climate protection strategies to date. The integration of measures that are equally conducive to public health and to climate protection and geared towards a more strategic approach toward prevention and health promotion would be the most promising starting point.

Indirect emissions caused by the medical care system can be cut through a more efficient use of medication and medical products. International carbon footprint studies show that the indirect GHG emissions associated with the purchase of medication and medical products account by far for the largest share in total GHG emissions of this sector. This calls for measures at the core of the medical care system: increasing efficiency by avoiding excessive medication and medication errors, evidence-based information about screenings and treatments, stronger integration of health promotion and health literacy in the medical care system. This requires research that provides evidence on those areas that have the strongest effects on health and the climate.

Regular checks of the monitoring and early-warning systems as well as the heat protection plans as to their effectiveness and accuracy are an important precondition for protecting the population against adverse effects of climate change. Austria has a number of monitoring and early-warning systems in place, which will become ever more important in the face of climate change. Whether and to what extent these systems will have to be adjusted under changed climatic conditions has not been studied yet. Identifying specific risk groups and regions with regard to extreme weather events such as heat, but also in combination with pollution, as well as the varied spread of pathogens and vectors may enhance effective protection against adverse effects.

Accessibility, targeted support and care of risk groups are considered pivotal in the protection of human health against extreme events, in particular against more intense and longer heat waves. People with low education levels and lower income, single persons, old and chronically ill persons – among them also migrants – are particularly affected by the consequences of climate change, but are often hard to reach. Raising awareness among the stakeholders in the health and social sector for the risk groups most likely to be affected is deemed to be of utmost importance. It needs to be ensured that these groups can be reached if necessary. Measures are effective when they strengthen the health literacy of these risk groups in a targeted way, for instance, through adequate information, but also by offering concrete support to those affected. This includes a higher level of care during heat episodes by physicians, nursing staff and volunteers. And it implies the provision of adequate support to the caregivers themselves.

Targeted adaptation and climate protection measures in health care require the integration of the topic of "climate and health" in education, continuing education and further training. To ensure both adequate professional care of vulnerable population groups and the development of climate protection measures in the health care sector it is essential to impart knowledge about the complex relationships between climate, health, demographics and health care. The potential of prevention and health literacy for the protection of health, but also specific knowledge about the reduction of GHGs are considered crucial leverage points. Including the topic of "climate and health" in education, continuing education and further training for all health professions (medicine, care, hospital

management, dietology) would significantly enhance the ability to take informed action. Similarly, this applies to putting greater emphasis on this topic in research-related university classes on sustainability, health and nutritional science.

In order to minimize the adverse health effects of climate change on the population or prevent them to the greatest possible extent, it takes measures that go beyond the health care sector. In addition to the measures in the health care sector, several other sectors are called upon to make important contributions to avoid negative health effects. These sectors include urban and spatial planning, the construction sector, transport infrastructure, tourism and adequate research funding. Last but not least it is vital to challenge the role and responsibility of global corporations who benefit from developments that are harmful to health and the climate.

It does not take long for health co-benefits of climate protection measures to manifest; they directly benefit the local population, reduce the burden on the public budget and thus contribute to achieving climate and health targets. The focus of the recommendations is on structural changes which encourage climate-friendly and health promoting life styles and nutrition. Health co-benefits are an argument for raising investments in climate protection. The key leverage points are:

- Diet: Concrete incentives to eat less meat but more fruit and vegetables would be a direct benefit for people's health.
- Mobility: The reduction of motorized traffic and institutional support of active movement improve air quality and thus have a positive effect on health.
- Urban planning and housing: Creating urban green areas and environmental zones to improve air quality, insulation of buildings and greening of facades and roofs which are relevant both in terms of climate protection and adaptation.

4.1 Introduction

From a scientific point of view, it is uncontested that climate change will have predominantly adverse effects on human health. The severity of the health effects on the population is significantly influenced by demographic developments (aging and migration) and by socio-economic inequality (Smith et al., 2014; Watts et al., 2015; Watts et al., 2017) (see Chapters 2 and 3). Those nations and population groups which are among the main culprits of climate change will be best able to protect themselves against its negative effects. This means that rich countries like Austria are not only required to protect their own populations, in particular vulnerable groups, against the inevitable climate effects, but also to make a firm contribution to climate protection.

Chapter 4 deals with adaptation measures that contribute to protecting Austria's population against direct and indirect health effects of climate change as well as with climate protection measures which, at the same time, contribute to the promotion of health. Health co-benefits of climate protection measures are considered pivotal leverage points for a transformation toward a climate-friendly society.

4.2 Impacts of Climate Change on Health Policy and Health Strategies

Adverse health effects of climate change are already being felt worldwide, including Austria, and will increasingly occur in future (Smith et al., 2014; APCC, 2014; Watts et al., 2017). The population is unequally affected by these effects. For this reason, Austria's health politicians need to act and launch adaptation measures to climate change in the field of prevention and care, particularly for vulnerable population groups, and initiate climate protection measures in the health care system.

With the Austrian Health Targets, a relevant health-policy framework for adaptation and emission reduction measures has been created that still holds great potential for developing ways how to meet the challenges related to climate change, demographic developments and health in the period until 2032 (BMGF [Federal Ministry of Health and Women's Affairs], 2017e). The actual implementation of the health targets, however, will largely depend on the political and financial commitment of the federal government, the federal provinces, the municipalities and the social security institutions.

In Austria, the stakeholders in the health care sector and health politics have been little concerned with climate change so far. In previous discussions, the focus, if any, has mainly been on adapting to the negative health effects of climate

change. The health care sector's contribution to climate change has been widely disregarded, which means there is clearly a need for action. Developing a climate strategy for the Austrian health care system would be an appropriate measure. Such strategy could both provide answers to the necessary climate-related need for adaptation, in particular against the backdrop of demographic developments, and define measures for the health care sector to reduce GHG emissions.

In other countries, establishing a separate coordination unit for sustainability and health has proven to be a successful structural measure (see the Sustainable Development Unit (SDU) in England) that might ensure the long-term implementation of a future climate protection strategy and that could work also in the Austrian health care sector at federal, provincial and municipal levels. Such initiative can build on the measures of Health Target 4 "To secure sustainable natural resources such as air, water and soil and healthy environments for future generations" (BMGF, 2017e).

An essential precondition for the successful implementation of climate adaptation and climate protection measures in the health care sector is successful cross-policy cooperation. In its latest status report on the environment and health in Europe (WHO Europe, 2017a), WHO Europe identifies the lack of intersectoral cooperation at all levels as the main obstacle on the road to the successful implementation of climate measures. This cross-policy connection is underpinned by the central role of the health targets in the implementation of SDG 3 "Good health and well-being" in Austria (Federal Chancellery [BKA] et al., 2017). Accordingly, the Federal Chancellery expressly points out that Austria's health targets also contribute to achieving some of the SDGs (BKA et al., 2017, p. 15). Taking greater account of the synergies and contradictions between SDGs and health targets would be conducive to their implementation. Likewise, an intensified collaboration that goes beyond Health Target 4 between health policy and climate policy leaves more room for maneuver and is suited to increase the effectiveness of the measures.

4.3 GHG Emissions and Climate Protection Measures of the Health Care Sector

The health care sector is a socio-economically significant and growing sector which, however, has not been taken into account in climate strategies so far. In industrialized countries, the health care sector accounts for a high and growing share in GDP. With a percentage of more than 10 percent of GDP, Austria ranks slightly above the OECD average (OECD, 2017c).

The health care system is responsible for restoring health, produces GHG emissions itself due to its energy consumption and the consumption of medical products and thus contributes to climate change. This, in turn, puts a strain on human health and leads to an increasing demand for health care services. All this at a time when public funding of health care is already stretched to its limits due to an increasing demand attributable to demographic developments and costly progress in medical technology (European Commission, 2015; Kickbusch & Maag, 2006). On that note, WHO is also calling on the stakeholders in the health care sector to engage in the fight against climate change (Neira, 2014) and emphasizes that the health care sector serves as a role model for other sectors (e.g. Gill & Stott, 2009; WHO & HCWH, 2009; McMichael et al., 2009; WHO, 2012).

To date, three carbon footprint studies on national health care sectors have been published (USA, England, Australia) that provide empirical evidence for the climate relevance of health care sectors in industrialized countries (Brockway, 2009; SDU & SEI, 2009 and updated versions SDU & SEI, 2010, 2013; Chung & Meltzer, 2009; updated version Eckelman & Sherman, 2016; Malik et al., 2018). The national carbon footprint studies published so far show that along with the growth of the sector, GHG emissions are also steadily rising. The figures yielded by these studies are not directly comparable due to differing calculation methods and different system demarcations, but they arrive at the same key statements: 1. The indirect GHG emissions attributable to the supply chain in the manufacturing of the products for the sector, in particular the production of medical drugs, by far exceed the direct emissions produced onsite. 2. Hospitals are the main sources of these emissions. 3. If no appropriate measures are taken, GHG emissions will continue rising steadily as the sector grows. A corresponding study on Austria's health care sector is currently in progress (Weisz et al., 2018). Intermediate results indicate a similar development.

Thus, the climate protection measures need to focus not only on direct GHG emissions but also on indirect emissions produced by this sector (i.e. emissions associated with the supply chain). As a logical consequence, climate protection in the health care sector cannot be organized in a marginal and isolated department, but rather has to be integrated into the sector's core activity, namely in patient care, because this is where essential climate-relevant decisions are taken (option for action). It is only by taking such an integrative approach, both in terms of health improvement and climate protection, that prevention and health promotion as well as the avoidance of inadequate patient care, such as incorrect assignments or excessive medication and medication errors, can become promising leverage points (option for action).

As, however, there is hardly any evidence available on the climate and environmental effects of the health care sector as well as their repercussions on health, in-depth empirical analyses are necessary to be able to assess the outcome of the medical treatment while also taking ecological side-effects and the resulting health effects into account (need for research).

Education and further training for health professionals in the fields of "climate and health" are an important approach

not only in the prevention of health effects caused by climate change, but also in the development of a more climate-friendly health care system (option for action). Including these topics in education and further training is also an important prerequisite for being able to ensure the protection of vulnerable population groups during heat waves. Similarly, this applies to putting greater emphasis on this topic in research-related university classes on sustainability, health and nutritional science. Including this topic in the school curricula would be a good opportunity to raise awareness among the population, thus strengthening the society's ability to act.

The key conclusion of this assessment is that a sustainable, climate-friendly health care system can be achieved by a paradigm shift of the prevailing system focused on medical treatment toward a prevention-oriented and health-promoting system that increases the effectiveness of health care services and prevents incorrect assignments and medication errors.

4.4 Adaptation Measures to Direct and Indirect Health Effects of Climate Change

Some strategies dealing with climate change adaptation put more emphasis on the topic of health, others less. The measures set out in the already existing national strategies could give more consideration to health effects. The challenges caused by the demographic development (e. g. increasing proportion of the elderly) are discussed to some extent, whereas in the concrete recommendations for action they receive little attention. The implementation of the measures might be stepped up by increased transdisciplinary and cross-institutional collaboration. This is specifically true if sectors like spatial and urban planning, the construction sector, natural hazard management and preventative disaster management are included, because in these fields both synergies with great potentials can be harnessed and adverse effects of an isolated perspective can be avoided.

Heat protection plans and warning systems are increasingly gaining in importance as a further rise in temperatures and consequently more frequent heat waves are to be expected. These plans are indispensable to be able to take timely preventive measures. For assessing the effectiveness of existing heat protection plans and warning services they have to be evaluated on a regular basis. During heat waves risk groups, like, for instance, elderly persons, chronically ill people and persons in need of nursing care, require particular attention. If the topic of health finds its way into education and further training and if targeted support and directions for action are provided both to caregivers and the persons affected, this will enhance the effectiveness. There is scientific evidence that heat has a negative impact on labor productivity. Especially people working outdoors are greatly affected by heat. For the protection of workers, it would be an important option for action to put statutory regulations in place.

A high number of research papers have been published dealing with climate change and heat in urban areas and including concrete recommendations. Studies have shown that having more green spaces in the city is beneficial to health. The extent to which this aspect is being considered in urban planning and urban development in Austria's towns and cities has not been evaluated. In this area, there is a need for research.

In addition to heat events, an increase in the frequency and intensity of other health-relevant extreme weather events, such as drought, heavy precipitation, thunderstorms and flood events has to be reckoned with in the wake of climate change (see 2.2). Monitoring and early-warning systems are essential to minimize hazards to people and material damage or ideally to avoid them. There is a need for research with regard to the development of risk management and adaptation strategies in Alpine municipalities which are faced with a decline in population and an aging population.

Due to the prolongation of the pollen season caused by climate change, a higher pollen concentration and a concomitant higher exposure, the risk of re-sensitization as well as the strain on persons already suffering from allergies are rising (currently ¼ of all people in Austria [*Statistik Austria*, 2015]). Especially the concentration of Ambrosia pollen in the air could be about 4 times higher by 2050 than today (Hamaoui-Laguel et al., 2015). This development can only be curbed by consistently fighting highly allergenic plants (Karrer et al., 2011). In urban planning, selecting proper tree species and bushes in public spaces can significantly lessen the pollen concentration of allergologically relevant species (Brasseur et al., 2017). Additionally, there is a complex relationship between the spread of allergenic species of plants and e. g. the development of air pollution in urban areas (nitrogen oxides, particulate matter, ozone, etc.), leading, in particular, to an increase in pulmonary diseases (hay-fever, asthma, COPD) (D'Amato et al., 2014). As a result of higher air pollution levels, pollen become more aggressive in terms of their allergenicity.

There is sound evidence that the injury patterns in tourism are shifting, in particular due to artificial snowmaking in winter. It is yet unclear whether this leads to a seasonal excessive burden on the health care system for want of any relevant research work on the situation in Austria in this regard. This is an opportunity for Alpine regions to develop specific offers that contribute to mitigating the health effects of climate change, in particular during heat waves.

4.5 Health Co-Benefits of Climate Protection Measures

Certain climate protection measures yield short-term and, above all, locally effective positive health effects. Since the late 2000s, the term "health co-benefits of climate change mitigation" has become well-established in international literature in this context (Ezzati & Lin, 2010; Haines et al., 2009; Ganten et al., 2010; Edenhofer et al., 2013; Smith et al., 2014; Gao et al., 2018).

Due to the longevity and global distribution patterns of the effects of climate protection measures and the short-term planning horizon of political decision-makers, these direct and immediate effects that benefit the local population are of particular political significance (Haines et al., 2009; Smith et al., 2014; Watts et al., 2015; Watts et al., 2017). In addition to the health benefit for the population, health co-benefits may (partially) offset the costs of climate protection measures through a reduction of health-related expenditures and an increase in labor productivity. As such economic assessments are still largely outstanding, there is a need for research in this regard.

At a global and national level, the transport and nutrition sectors rank among the main contributors to GHG emissions and to lifestyle diseases. Little exercise combined with western dietary patterns is particularly harmful to health. In addition to the obesity rate (OECD, 2017b), this becomes evident in an increased prevalence of cardiovascular diseases, type 2 diabetes and certain types of cancer and leads to premature mortality (WHO & FAO, 2003; Lozano et al., 2012).

Studies on the co-benefits of changing dietary patterns reveal that meat consumption plays a key role both in terms of climate and health, and that a reduction in meat production and meat consumption has the greatest effects on both areas. It is largely unclear though how such change in dietary behavior may be achieved. There is a need for research in this regard. It shall be stated that there is no evidence whatsoever that "soft measures", as preferred by politicians also in Austria, are effective in substantially changing prevailing nutritional trends. Literature shows that price signals accompanied by targeted information campaigns and further supporting measures such as advertising bans can be highly efficient in achieving fundamental changes in the prevailing dietary patterns (WHO, 2015b; Thow et al., 2014) (need for research, need for action). The fact that the food industry usually opposes price incentives through tax breaks and advocates "soft measures" is considered a major barrier in this context (Du et al., 2018).

Based on the studies conducted on the co-benefits of changed mobility behavior, it can be said in summary that a shift in mobility from private motorized traffic towards active forms of mobility such as walking and cycling creates co-benefits, because active mobility works against the existing lack of exercise including the associated secondary diseases, improves air quality and reduces GHG emissions. This was already demonstrated to be true for the three largest cities in Austria (Wolkinger et al., 2018). In this context, introducing structural measures that make active mobility "irresistible" may be a promising approach. International studies illustrate how a transition towards bike-friendly cities can be achieved (Alverti et al., 2016; Dill et al., 2014; Larsen, 2017; Mueller et al., 2015; Mueller et al., 2018).

Air traffic as a special topic also needs to be addressed in connection with co-benefits, as the harmful emissions it produces have a strong adverse effect not only on the climate but also on human health. This is particularly true for particulate matter, secondary sulfates and secondary nitrates. At the same time, there are numerous barriers when it comes to implementing a reduction, indicating that there is an increased need for research with regard to feasible transformation paths, especially with a view to the acceptance of the population.

Chapter 5: Synopsis and Conclusions

5.1 Introduction

The final chapter summarizes the state of knowledge on health, demography and climate change as discussed in the preceding chapters. Based on this summary, conclusions will be drawn and options for action for Austria will be proposed.

Since this report focuses on proposals for sustainable transformations at the level of society as a whole, the options for action and measures discussed in this synopsis concentrate particularly on the macro level of measures that can be initiated by policymakers. However, in order to be successful, the dynamics at the other levels are also taken into account.

To allow a better classification of priorities regarding the various health-relevant developments, a two-stage assessment procedure was carried out. First, based on their state of knowledge, climatologists estimated the changes in climate indicators with potentially negative effects on health (see Table 2.1). Based on this estimation, the interdisciplinary group of experts collaborating on the preparation of this Assessment Report used three groups of criteria for their assessment: affected persons (proportion of affected persons among the population, social differentiation, demographic differentiation), health effects (mortality, physical and mental morbidity) and options for action (at individual level, health care system or government level). According to this assessment, the highest priority is given to those climatic phenomena where the combined effect occurs that a relatively high percentage of the population (including highly vulnerable groups) has to expect serious health effects. The differing estimates within the criteria explain the gradation of the ascribed priority levels. For practical reasons, individual related meteorological parameters, for which similar estimations were to be expected, were merged into larger groups. This small-scale expert assessment is to be seen as cross-topic and thus integrative guidance – it cannot replace a strictly scientific analysis.

The assessments showed a clear categorization into three priority levels according to which the individual issues should be addressed (Table 5.1): Heat is at the top of the table with the highest priority, followed by pollen and air pollutants together with extreme events such as heavy precipitation, drought, flood events, and mass movements. Little significance, on the other hand, is attributed to cold-related events, shortage of water or food and pathogens in water and food. This prioritization results from combining the share of the affected population and the scope of the health effect and – to a lesser extent – the magnitude of the change of climate indicators (time horizon until 2050). The high priority assigned to the group of "air pollutants" is remarkable, although uncertainties as to their further development are high. As the collective term comprises both ozone (upward tendency) and particular matter concentrations (downward tendency due to warmer winters), the findings are hard to interpret. The events particularly affecting economically disadvantaged persons as well as elderly and ill persons mainly fall into the highest priority category, while these groups particularly benefit from the cold events indicated at the bottom of the table. Any adverse health effects of crop failures on staple food are less likely in Austria.

The table clearly shows that both at individual and government levels options for action are identified – generally more at government level. No differentiation was made between these as to their nature, i.e. pre-emptive measures as well as crisis interventions and follow-up measures are included. Not all measures are part of the health care system, as the example of an imminent increased use of pesticides in farming shows. Only in one single case is the individual person thought capable of dealing with more options for action than the government – namely in connection with icing.

In the statements below, special attention is paid to the fact that many of the measures that are important in terms of climate protection have positive "side effects". This is especially true for health, which is why the measures are advisable even in the absence of any climate effect.

Priority Level	Climate-induced Phenomena	Trigger Events and/or Potential Health Effects	Change in Climate Indicators	Proportion of Affected Population Groups	Effect on Socially Weak Groups	Effect on Elderly and Ill Persons	Level of Health Effect (Morbidity/Mortality)	Individual Options for Action	Government Options for Action
3	Heat	Steady increase and more, longer, hotter heat waves, less pronounced drop in overnight temperature	3	3	++	+++	3	2	2
2	Pollen	Extended seasons and more allergenic neobiota	2	2	+	+	2	1	1
2	Air pollutants	Climate-induced increased effect of ozone, decrease in particulate matter	1	2	+	++	2	1	2
2	Heavy precipitation	More frequent and intense	2	1,5	+	+	2	1	2
2	Drought	Water and food shortage	3	1	++	++	2	1	2
2	Flood events	More frequent and intense	1	1,5	+	+	2	2	2
2	Mass movements	Mudslides and landslides	2	1	+	+	2	1	2
1	Increased use of pesticides	Due to increased occurrence of vermin	2	2	+	+	1	1	3
1	Mosquitoes	Malaria	2	1	+	+	2	1	2
1	Thunderstorms	Increased and fiercer	2	1	+	+	2	1	1
1	Ticks	Surge in ESME/TBE, Lyme disease	1	1		+	2	2	2
1	Snow masses	Increasing events	1	1		+	2	1	1
1	Storms	Increased and stronger whirlwinds and tornadoes	1	1	+	+	2	1	1
1	Rodents	Leptospirosis, HFRS, tularemia	1	1		+	2	1	1
1	Pathogens Food	Campylobacter, salmonella, *E. coli* & vibrio infections, mycotoxins	1	1	+	+	1	2	2
1	Pathogens Water	*Giardia lamblia*, *E. coli*, vibrio and cryptosporidium infections	1	1			1	1	2
1	Fog-prone areas	Risk of accidents	1	1			1	1	1
1	Crop failures	Food shortages	1	1	+	+	1	1	2
1	Water shortages	Less accumulation of ground water	1	1	++	+	0	0	2
0	Icy traffic areas	Risk of accidents	0	0		+	1	2	1
0	Cold	Frostbite, strain on the immune system	-1	-1	++	+	2	2	2

Increasing certainty of statement — Overall range of effects — Inverse effect (-1) — No effect (0) — Increasing effect (1, 2, 3) — Increasing options for action (1, 2, 3)

Table 5.1: Prioritization of health-relevant climate-induced phenomena: The expert estimation of this prioritization combines changes in the climate indicators, affectedness and health effects, with 3 having the highest and 0 having the lowest priority. The darker the colors of the individual estimations, the more certain they are. The events having the highest negative effects on socially weak groups as well as elderly and ill persons are indicated with +++. 3 denotes the highest potential for individual and government options for action.

5.2 Health Effects of Climate Change

This section presents a summary of the health impacts of climate change which will be most important in the decades to come.

5.2.1 Heat in the City

Critical trends

- Cities are particularly sensitive to heat because the rise in temperature due to high building density, additional heat sources and high levels of soil sealing (heat islands, high heat storage capacity, lack of green areas) is particularly pronounced (high agreement, robust evidence[1]).
- At the same time, cities experience the largest population growth (high agreement, robust evidence).
- Elderly and ill people in cities are vulnerable on two accounts: they are more health vulnerable and often less well connected, which is why they require more care (high agreement, medium evidence).
- The higher levels of air pollution in cities aggravate the adverse health effects of heat (high agreement, medium evidence).

The frequency distribution of the daily maximum temperatures during the summer months in Austria has shifted significantly toward higher temperatures. It is to be expected that by the middle of this century, the length of heat episodes (periods with daily maximum temperatures of at least 30 °C) will double; by the end of the century, in the worst case, there may be a tenfold increase in the number of hot days (Chimani et. al, 2016). Less of a drop in evening temperatures also adds to the problem; the number of nights with a minimum temperature above 17 °C has gone up by 50 percent in Vienna (comparison of 1960–1991 and 1981–2010) (high agreement, robust evidence).

Health effects

In statistical terms, the number of deaths per day increases at a daily maximum temperature above 20–25 °C. People can adapt to temperature shifts in the long run, but there are limits to physiological adaptation. Furthermore, reduced night-time cooling affects the ability to recover. The heat wave in August 2003 resulted in almost 40,000 excess deaths within 14 days in 12 European countries, compared to the long-term average during this season. The "Cost of Inaction" study (Steininger et al., 2015) demonstrated that in Austria, under the assumption of a moderate climate change and medium socio-economic scenario, 400 heat-related deaths per year are to be expected around 2030, while 1,060 annual deaths will be attributable to heat by the middle of the century, with the majority of casualties occurring in cities. Economically weaker persons and migrants are often more strongly affected due to their housing situation in densely built-up areas with few green spaces, poorer building structure und restricted night-time ventilation due to traffic noise (high agreement, medium evidence).

Heat stress generally leads to diminished quality of life, reduced concentration and productivity as well as increased stress on the cardiovascular system, the respiratory system and, in extreme cases, even to death (high agreement, robust evidence).

Options for action

1. There is a considerable need for adaptation when it comes to urban planning and buildings: ventilation corridors, green areas such as parks, tree-lined avenues, green roofs or facades (WHO Europe, 2017d; Bowler et al., 2010; Hartig et al., 2014; Lee & Maheswaran, 2011). The risk of cardiovascular diseases mortality is statistically significantly reduced by access to green spaces (Gascon et al., 2016). Urban green spaces and open water surfaces also have a positive effect on air quality and can help reduce the mortality related to air pollution (Liu & Shen, 2014) (high agreement, robust evidence).
2. The Austrian Strategy for Adaptation to Climate Change lays down comprehensive urban planning and structural measures as well as precautionary measures in relation to behavior, for example, heat protection plans and neighborhood assistance during heat waves (see also Chapter 5.3). It has to be considered that climate adaptation measures do not run counter to climate protection measures, as would be the case with fossil-fuelled air-conditioning systems, which do not only increase greenhouse gas emissions but also, while cooling the interior spaces, heat up the exterior spaces, i.e. the city (high agreement, medium evidence).
3. The decrease in cold-related deaths cannot offset the increase in heat-related deaths (high agreement, medium evidence). There is a risk that, due to changes in the Arctic and the Gulf Stream, longer and colder winters may occur in Austria; in this case, the number of cold-related deaths might even rise, the air quality could worsen due to the increased demand for heating, and greenhouse gas emissions could increase (Zhang et al., 2016) (medium agreement, low evidence).

1 Following the IPCC, this report employs a two-dimensional scheme for dealing with uncertainties. High/medium/low agreement indicates to what extent the scientific community agrees on certain facts. Robust/medium/low evidence indicates how reliable the existing evidence is with regard to the facts (i.e. information from theory, observations or models that show whether an assumption or assertion is valid).

5.2.2 Other Extreme Weather Events and their Health Effects

Critical trends

Although the connection between the observed changes and climate change based on strictly scientific criteria has been statistically validated only in a few cases, such as heat periods, for physical reasons, more intense and abundant precipitation, longer periods of drought or fiercer storms can be expected in the wake of climate change (medium agreement, medium evidence). As illustrated by the COIN study (Steininger et al., 2015), even today, costs for damage caused by extreme events are considerable in Austria, and soaring.

Health effects

Extreme weather events can have a considerable impact on health, ranging from illnesses and psychological trauma to death. The direct effects of extreme weather events include injuries caused by falling objects and objects that are blown or washed away (e. g. roof tiles and window panes). Indirect (secondary) effects include, for example, bacterial infections triggered by poor water quality following floods. In addition, intense precipitation and floods, in particular when the soil is compacted by heavy agricultural machinery, can facilitate ponding and hence create potential habitats for insects and other disease vectors and thus increase the risk of infectious diseases. Tertiary effects include, for example, the impact of migration on the health care system, triggered by extreme events in other parts of the world. Due to the high standard of the Austrian health care system, the effects of (climate-induced) migration of people on public health in Austria currently do not pose a serious problem.

In conclusion, it can be said that the health effects of extreme weather events depend on the exposure, i.e. frequency, extent and duration of the change, the number of people exposed to the events and their sensitivity. Extreme weather events make good headlines and have high economic significance (see COIN study), but the number of people exposed to them is – disregarding extreme temperature events – relatively small; thus the immediate health effects of extreme weather phenomena in Austria are relatively low (high agreement, medium evidence). Nevertheless, extreme events can cause injuries or deaths and, in the case of existence-threatening material damage, post-traumatic stress disorder.

Options for action

1. Integrated event documentation: The records of the various stakeholders are largely high-quality and parts are already available on Internet portals (Matulla & Kromp-Kolb, 2015). Harmonizing and merging this information into one database modeled on international examples (see StartClim project SNORRE; Matulla & Kromp-Kolb, 2015) would facilitate the analysis and preparation of tailored measures (high agreement, medium evidence).
2. Strengthening self-provision: Risk management that is based on the collaboration of public and private stakeholders could further reduce damage and health effects. According to experts, the majority of the Austrian population is at the first out of five stages of risk provisioning (Fig. 5.1): precontemplation. To enable self-provisioning, progress has to be made towards the stage of contemplation and further to active protective behavior (the stage of preparation and higher) (Rohland et al., 2016). Potential approaches to strengthen self-provision are the inclusion of this topic in school curricula, targeted information (events and brochures), advisory services and incentives for preventative disaster management, like, for instance, technical and financial support as well as reduced insurance premiums for well-prepared households.
3. Differentiated handling of groups of persons in the event of a disaster: Damyanovic et al. (2014) demand that more attention be given to the different needs and potentials of diverse groups of persons in situations of disaster. For example, elderly persons are vulnerable but, at the same time, they have experience that is valuable for effective disaster management. People with few social contacts require special attention. Other aspects to consider are gender-specific, often complementary differences when it comes to how people perceive disasters. The involvement of a good mix of diverse groups in the preparation of disaster management plans, in particular at municipal level, ensures that both their needs are taken into account and their potential is used in dealing efficiently with disasters (medium agreement, medium evidence).

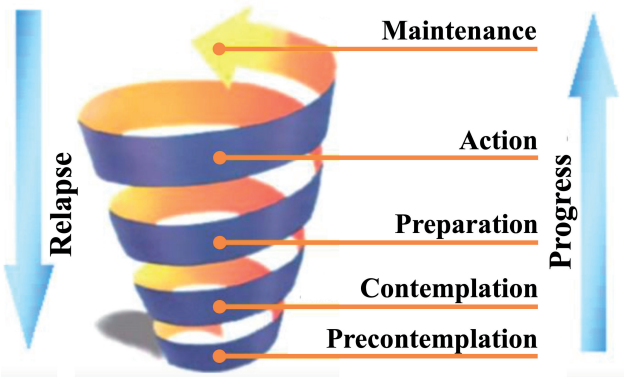


Fig. 5.1: Transtheoretical model (TTM) as a spiral (Rohland et al., 2016)

5.2.3 Increased Incidence of Infectious Diseases due to Global Warming

Critical trends

Climate change (in particular global warming) also affects pathogens and vectors of infectious diseases and consequently increases the probability that certain infectious diseases will emerge in Austria (APCC, 2014; Haas et al., 2015; Hutter et al., 2017) (see Supplement: Vector-borne diseases [in German]). These range from viral diseases caused by insects emerging for the first time in a region, bacterial infections triggered by decreasing food and water quality up to wound infections. The incidence of these infectious diseases is co-determined by complex interrelations, ranging from globalized traffic, people's temperature-dependent behavior and precipitation conditions to the survival rate of infectious agents – depending on the water temperature (high agreement, medium evidence).

Health effects

Climate change will have an effect on the occurrence of mosquitoes as vectors of diseases in Europe (ECDC, 2010), as subtropical and tropical mosquito species introduced to Europe, and also to Austria, mainly through globalized trade and travel (Becker et al., 2011; Dawson et al., 2017; Romi & Majori, 2008; Schaffner et al., 2013) (especially of the Aedes species: tiger mosquito, Asian bush mosquito, etc.) will find better survival conditions here in future. The geographic distribution of vectors is expected to expand, in particular at Northern and altitudinal limits (Focks et al., 1995). It could be demonstrated that some of our indigenous mosquito species may also transmit infectious diseases previously not seen in Austria, such as the West Nile virus or the Usutu virus (Cadar et al., 2017; Wodak et al., 2011). Moreover, an increased distribution of sand flies and Dermacentor ticks ("wood ticks") as potential vectors of several infectious diseases (Leishmania, TBE virus, Crimean-Congo hemorrhagic fever virus, Rickettsia, Babesia, etc.) could be observed (Duscher et al., 2013; Duscher et al., 2016; Obwaller et al., 2016; Poeppl et al., 2013) (see Chapter 3.2.1).

The importance of all mosquitoes as vectors of diseases strongly depends on local weather factors, such as humidity. The concrete relationships, however, have not yet been sufficiently studied to allow conclusive statements to be made (Thomas, 2016) (see Supplement: Vector-borne diseases [in German]).

Furthermore, if global warming progresses, food-borne diseases (e.g. campylobacter and salmonella infections, contamination with mycotoxins) might occur in people more often (Miraglia et al., 2009; Seidel et al., 2016; Versteirt et al., 2012); the high national food production standards, however, – in particular well-functioning cold chains – do not give reason to expect any significant implications for the incidence of these diseases in Austria in the near future (high agreement, medium evidence) (see Chapter. 3.3.5 Food, full volume in German p. 190).

Options for action

Currently, the following key leverage points for adaptation measures related to these health risks can be identified:

1. Monitoring of vectors and new infectious diseases: An international monitoring network allows for early collection of information on changes in the geographical distribution of vectors, in particular of mosquitoes, sand flies and ticks. In Austria, monitoring systems for 44 mosquito species and the West Nile virus are in place (AGES, 2018b). There is a need for research with regard to forecasts on possible extensions of propagation areas of potential vectors. The most important newly emerging infectious diseases related to climate change have already been included in the list of notifiable diseases (BMGF, 2017a) and are therefore subject to close monitoring. A review of the Austrian food monitoring system in this regard and, if necessary, its adaptation by AGES (BMGF, 2017g) could further improve food safety.
2. Control of vectors: In its current handbook summarizing international best practices and experiences focusing on the most relevant mosquito species, the European Centre for Disease Prevention and Control (ECDC, 2017) states that there is still insufficient evidence for the best possible control measures and recommends assessing, publishing and exchanging knowledge on control measures as well as informing the public. The targeted fight against dangerous species is particularly important in order not to deprive amphibians and other animals of their basic food resources by exterminating non-hazardous insects (e.g. non-biting midges) (high agreement, medium evidence). AGES has already published an information folder on how to control mosquitoes in residential areas without using ecologically hazardous poisons (AGES, 2015).
3. Control of infectious diseases: A pivotal factor in combating infectious diseases in time is their early detection and, therefore, increased awareness among health professions and the population. The major climate-induced infectious diseases are highly treatable and have rarely occurred in Austria so far (high agreement, robust evidence). Since the first symptoms of these diseases are often not correctly diagnosed by medical practitioners in primary care, the targeted development of expertise in health services (professional competence) and among the population (health literacy) implemented by AGES and others can make a substantial contribution. Furthermore, including the issue of early detection of climate-induced infectious diseases in the basic education of health professions can also be a contributing factor (see Chapter 5.3.3). AGES is the compe-

tent institution responsible for regularly reviewing the processes and structures of early detection (including laboratory diagnostics) and the appropriate responses to outbreaks and for making adjustments, if necessary. In this context, the re-orientation of the public health service as laid down in the Target-based Health Governance agreement (Zielsteuerung-Gesundheit, 2017) can have a supporting effect (establishing nationwide pools of experts in new infectious diseases).

4. In the field of food, adapted food monitoring for climate change-related monitoring and – if necessary – adaptation of the guidelines regarding best agricultural and hygienic practices can contribute to health protection. In this field too, AGES or the ministry responsible for agriculture can take actions. It should be pointed out that the use of disinfectants has negative effects on the environment and humans and is, in most cases, especially in households, absolutely unnecessary (see Stadt Wien, 2009).

5.2.4 Spread of Allergenic and Poisonous Species

Critical trends

Climate change, globalized trade and travel as well as modified land use lead to the spread of plant and animal species that were previously not indigenous in Europe and that have various impacts on public health (Frank et al., 2017; Schindler et al., 2015). In particular, the spread of allergenic plant species, most notably of common ragweed (Ambrosia artemisiifolia) has been observed (Lake et al., 2017). Ragweed pollen loads are projected to increase significantly in Europe, a trend which is reinforced by complex climate shifts (increased air humidity, the "fertilizing effect" of CO_2 and nitrogen oxides, earlier flowering and pollination times due to warming and the extension of the pollen season; effect of ozone) (Frank et al., 2017; Hamaoui-Laguel et al., 2015). Furthermore, the German Assessment Report on climate and health expects the emergence of another six new plant species with clear potential of being harmful to health (Eis et al., 2010) (see Chapters 3.3.2 and 3.3.3, full volume in German pp. 190 and 191 respectively).

In addition, extended growing seasons as a result of climate change lead to increased and longer pollen exposure. The concentration of airborne pollen has risen mainly in urban areas. Examinations of the daily airborne pollen counts of various allergenic plants in the United States over the past two decades have demonstrated that the amount of airborne pollen is steadily increasing and the pollen season lasts longer (Zhang et al., 2015) (high agreement, robust evidence).

Health effects

The spread of allergenic plant species will presumably have far-reaching consequences for the health of citizens. In a complex interaction with air pollutants in urban areas (nitrogen oxides, particulate matter, ozone, etc.), these plants cause a rise in respiratory diseases in particular (hay-fever, asthma, COPD) (D'Amato et al., 2014). An increase in air pollutants makes pollen allergens more aggressive. Allergic diseases are already common in Europe, and their prevalence and severity are on the rise. It is estimated that in 10 years' time 50 percent of all Europeans might suffer from allergic diseases (Frank et al., 2017). In 2009, the prevalence of ragweed pollen allergy in Austria was not as high as in the Eastern neighboring countries, which are strongly affected by ragweed. The sensitization rate to ragweed pollen among those suffering from allergies stood at around 11 percent in Eastern Austria in 2009 (Hemmer et al., 2010).

Based on extreme climate scenarios and the assumption that appropriate adaptation measures will not be taken, the health burden on the population is calculated to be significantly higher in 2050. Consistent control of highly allergenic plants can yield substantial savings in therapy costs. The health effects of the spread of *Ambrosia* were simulated under different climate scenarios for Austria and Bavaria, and high resulting treatment costs for allergies were assumed (Richter et al., 2013) (high agreement, medium evidence).

Options for action

1. Nationwide monitoring: The establishment of a nationwide monitoring system to record the spatial and temporal spread of *Ambrosia* and other invasive allergenic species as well as a corresponding warning system for the population has not been completed and can contribute significantly to mitigating health effects on the population (high agreement, medium evidence).
2. Evaluation of measures: The Austrian Strategy for Adaptation to Climate Change (BMLFUW, 2017b) prescribes measures to control existing populations of allergenic species, including the establishment of a coordination unit involving the relevant stakeholders and municipalities. Through targeted control measures (e. g. mowing or weeding before seed formation in *Ambrosia*) and the systematic obligation to report and control *Ambrosia*, several European countries achieved a substantial reduction in population sizes (Ambrosia, 2018). Providing a legal basis for the control measures, after re-assessing the evidence for Austria, in coordination between the federal government and the federal provinces/municipalities and in cooperation with the Austrian Chambers of Agriculture and the nature conservation authorities may contribute significantly to controlling *Ambrosia* in Austria.
3. Information: AGES and the Austrian Water and Waste Management Association (ÖWAV) are currently offering

public information on *Ambrosia* including control measures (AGES, 2018a; ÖWAV, 2018); however, taking a far more active public relations and information approach to create the necessary problem awareness among the population and agricultural stakeholders (e. g. bird food manufacturers) may significantly enhance the efficiency (medium agreement, medium evidence).

4. Need for research: The state of knowledge regarding the spread and impact of allergenic plant species in Austria is low and focuses on a few species; consequently, there is a great need for research into species that have been little explored but also into the appropriate management of health risks (BMLFUW, 2017b; Schindler et al., 2015).

5.3 Socio-economic and Demographic Factors Influencing the Health Effects of Climate Change

5.3.1 Demographic Development and (Climate-induced) Migration

Critical trends

Austria's population is growing and ageing, characterized by a shrinking proportion of people of working age but a consistent proportion of children and adolescents. The effects of aging are mitigated by immigration, in particular by the influx of young adults. Austria's population is growing mainly in the urban regions, while peripheral districts experience education and job-induced population declines and at the same time stronger population aging (see Chapter 2.3.1, full volume in German p. 145) (high agreement, robust evidence).

International migration could counterbalance the lack of workforce and contributors to the social security system if appropriate integration efforts are made. Because of the political sensitivity of the issue, immigration is the most uncertain component of the future changes in population structures. The main variant of the population forecast prepared by Statistics Austria (Statistik Austria, 2017a) assumes an annual net migration of about 27,000 people in the long term (period from 2036–2040). The strongest growth is forecast for Vienna. Thus, Austria's capital will have the youngest population of all federal provinces (high agreement, robust evidence).

Like other Western and Central European countries, Austria is affected by climate-induced migration, albeit to a lesser extent, mainly as a potential target country (Millock, 2015). However, there is not enough research and consistent discourse on climate-induced migration and its complex interrelations to be able to deliver reliable forecasts for the development in specific regions (Grecequet et al., 2017; Schütte et al., 2018; Black, Bennett et al., 2011).

Due to its aging population, Austria is expected to see an increase in the incidence rate of chronic diseases like, for instance, dementia, respiratory diseases, cardiovascular diseases and malignant tumors (malignomas), including all health implications following in their wake. What is also remarkable is the relatively high share of mental disorders in old age: More than half of all mental disorders occur in the population aged 60 and over (HVB & GKK Salzburg, 2011).

Health effects

Older population groups: People aged 60 and over are especially vulnerable to the effects of climate change, in particular to heat, because a high proportion of them suffers from cardiovascular diseases, diabetes and mental diseases (Becker & Stewart, 2011; Bouchama et. al., 2007; Hajat et al., 2017; Haas et. al., 2014; Hutter et. al., 2007). The higher incidence of extreme weather events is expected to increase the mental health stress among the elderly population in the future (Clayton et al., 2017).

Population groups with a migration background: The health effects of climate change are closely linked with the shortage of other socio-economic resources, for example, a lack of education and insufficient financial means, various structural, legal and cultural barriers, limited access to regional health infrastructure, unfavorable housing conditions, etc. The level of vulnerability is particularly high among refugees, which is a result of the hardships experienced during flight and the associated physical strain and mental stress (Anzenberger et al., 2015). The health risk of transmitting imported diseases, however, is extremely low, even at close contact (Beermann et al., 2015; Razum et al., 2008).

Options for action

In particular, the rise in the share of the elderly population combined with this group's high percentage of chronic, somatic and mental diseases make adaptation measures a priority. In this context, actions can be based on existing measures to address the care deficits of this group (BMGF, 2017c; Juraszovich et al., 2015). The following options for action seem appropriate:

1. Targeted measures for strengthening health literacy of the particularly vulnerable and growing target groups (elderly people, people with a migration background) (BMGF, 2017b; BMLFUW, 2017f) (see Chapter 5.3.3); in particular, the utilization of multicultural resources in the personnel management of health institutions (diversity management) and of cross-cultural medicine and care (high agreement, medium evidence).

2. Target group-specific prevention, promotion of health and treatment in the field of mental health and disorders, in particular for elderly people and people with a migration background (Weigl & Gaiswinkler, 2016).
3. Target group-specific enhancement of the living conditions of the aforementioned main target groups with regard to the health effects of climate change. Development of a "Health (and Climate) in all Policies" approach (BMGF, 2017b; WHO, 2015a; Wismar & Martin-Moreno, 2014) (see Chapter 5.5.2).
4. Research into the relationship between demographic development (in particular aging, migration, urbanization, socio-economic status) on the one hand, and health and the climate effects, on the other hand, to develop target group-specific and regional options for action regarding the health care system and living conditions in rural and urban areas (Steininger et al., 2015).
5. Research into the (positive) effects of a "sustainable" lifestyle (close to nature, socially secured, less competitive, showing greater solidarity, socially and ecologically committed) on psychosocial health and at the same time on climate protection (low agreement, medium evidence).

5.3.2 Different Levels of Vulnerability and Fair and Equal Opportunities with Regard to Climate-induced Health Effects

Critical trends

Morbidity, mortality, life expectancy and satisfaction differ by biological and socio-economic parameters, representing health inequalities in society (BMGF, 2017b). These inequalities are exacerbated by climate-associated changes. Children (particularly infants and young children), elderly (and, in particular, very old) people as well as chronically ill people or people with health-related impairments typically have a much lower biological ability to adapt to climate burden. In addition, the working and housing situations are a crucial factor for direct climate-related exposure of people (e. g. heavy physical work outdoors on construction sites and in farming, no green areas close to home in cities, over-occupied apartments, homelessness). The different levels of vulnerability to climate change are aggravated in particular by socio-economic factors, such as risk of falling into poverty, low education level, unemployment and a migration background (see Chapter 5.3.1) (high agreement, medium evidence).

According to EU-SILC (*European Community Statistics on Income and Living Conditions*), 14 percent of those living in Austria are to be classified as being at risk of poverty and exclusion. Large families, lone-parent households, migrants, women of retirement age, the unemployed, unskilled workers and people with low education levels suffer from a significantly increased risk of falling into poverty. Even today, socio-economic inequality is contributing to health inequalities: In Austria, persons with no more than compulsory education show a life expectancy 6.2 years shorter than that of university graduates (Till-Tentschert et al., 2011).

Both the United Nations (Habtezion, 2013) and the European Parliament (European Parliament, 2017) point out that women are disproportionately more vulnerable to the effects of climate change because they are hit particularly hard by disasters and flight.

Health effects

It is therefore reasonable to estimate that certain population groups are affected by a combination of several factors that substantially reduce their opportunities to adequately cope with the climate-related (health) effects. Accordingly, previous evidence has shown that disadvantaged groups were particularly affected by climate-related events, such as heat and natural disasters; this trend was often exacerbated when combined with other vulnerabilities, for example age (high agreement, medium evidence). The heat wave that struck Vienna in 2003, for instance, led to a significant increase in the number of fatalities in low-income districts in particular (Moshammer et al., 2009).

However, health-related climate effects have rarely been investigated with social inequality in mind (see, for example, Haas et al., 2014). The discourse (in German-speaking countries) on fair and equal opportunities in health in the context of "*Health in all Policies*" has also made little reference to climate effects so far (BMGF, 2017c; FGÖ, 2016; Kongress "Armut und Gesundheit", 2017).

While inequality regarding the (health) effects of climate change has been identified as a key factor on a global scale (Islam & Winkel, 2017; WHO Europe, 2010a, 2010b) and the various interdependencies between socio-economic status, health and climate have also been accounted for in the conceptual framework of the Sustainable Development Goals (SDGs) (Prüss-Üstün et al., 2016), this issue has not been given sufficient consideration in a conceptual framework in the strategic and political discussion on climate adaptation in Austria so far (see, for example, BMLFUW, 2017b).

Options for action

Growing inequality and its effects on health in the OECD countries (Mackenbach et al., 2008; OECD, 2017a) imply that priority should be given to careful analyses, development forecasts and action programs for fair and equal opportunities in health in Austria. The benefits for the labor market, the economic development and the well-being of the population are generally estimated to be substantial (Mackenbach et al., 2007; Mackenbach et al., 2011; OECD, 2017a). At an inter-

national level, evidence-based recommendations for achieving health equity are available (WHO, 2008).

The low level of research and the lack of political discourse on fair and equal health opportunities, in the face of increasing climate effects in Austria, clearly illustrates that there is a deficit in cross-policy cooperation in science, public administration and politics (WHO Europe 2010a; WHO, 2014) (see Chapter 5.5.2). The various interdependencies between public health, equal opportunities and sustainable development of societies are discussed within the scope of the SDGs (Prüss-Üstün et al., 2016). The most recent report issued by the Federal Chancellery (BKA et al., 2017) on the implementation of the SDGs in Austria specifically refers to equal opportunities as a key goal for a sustainable society not only in the field of health (Goal 3), but also in the field of education (Goal 4).

Options for action aimed at reducing the differences in the population's vulnerability to the health effects of climate change are therefore identified both based on the Austrian Health Targets and in the field of research. In addition to Health Target 2 "Fair and Equal Opportunities in Health", Health Target 1 "Health-promoting Living and Working Conditions", Health Target 3 "Health Literacy" and Health Target 4 "Sustainable Natural Resources" (BMGF, 2017b, 2017d, 2017e) also address various aspects of fair and equal opportunities in health.

1. Building on the measures of the Austrian Health Target 2 "Fair and Equal Opportunities in Health", in particular with regard to poverty alleviation, the aggravating factors of climate change can be integrated by way of targeted support measures in the fields of life and work environments (BMGF, 2017b) (see Chapter 5.3.3). By setting up a coordination and exchange platform mirroring a "community of practice" (see also first experiences gained in Austria: [Partizipation, 2018]), it is possible to support the hands-on approach when implementing these measures (medium agreement, low evidence).
2. Cooperation across policy fields with regard to fair and equal opportunities can be promoted within the scope of pursuing the SDGs in Austria. To this end, intensified cooperation and coordination (e. g. by the Austrian Federal Chancellery) is desirable, both horizontally between sectors such as public administration, politics and other areas of society (business, civil society) and vertically between the federal, provincial and municipal levels (see Section 5.5.2).
3. The particular vulnerability of women and girls can be addressed by taking account of gender-specific analyses of the impact of climate change, women's increased participation and gender equality in the decision-making processes on adaptation strategies (European Parliament, 2017).
4. Interdisciplinary research projects on health-related equal opportunities in the light of climate change play a pivotal role (high agreement, low evidence). Research funding provided by the Austrian Climate and Energy Fund, by other research funding institutions, by the federal ministries and the federal provinces may provide substantial insights as to which targeted measures to take in order to bring back into balance health-related inequalities of particularly disadvantaged population groups and highly affected regions.

5.3.3 Health Literacy and Education

Critical trends

High health literacy helps to better understand questions of physical and mental health and make appropriate health decisions (Parker, 2009). Low health literacy has a couple of negative effects on health for those concerned, for example low levels of treatment adherence, delayed diagnoses, poor self-management skills and an increased risk of developing chronic diseases (Berkman et al., 2011). Poor health literacy results in high health care costs (Eichler et al., 2009; Haun et al., 2015; Palumbo, 2017; Vandenbosch et al., 2016; Vernon et al., 2007).

According to a representative survey, Austria lags far behind when compared internationally (HLS-EU Consortium, 2012): 18 percent of the respondents had inadequate and 38 percent problematic health literacy. With regard to fair and equal opportunities, limited health literacy is a particular problem in Austria because higher proportions of people with limited health literacy are found among people with poor health status (86 %), with little money (78 %) and those who are 76 years or older (73 %) (Pelikan, 2015). Limited health literacy, however, cannot be attributed to a lack of cognitive skills at personal level (Rowlands et al., 2013) but is to be regarded as a problem at system level. This implies that, when it comes to the climate-related need for adaptation, measures at system level should be given priority (medium agreement, medium evidence).

Health effects

People with low education levels, people with low income, older people living alone – also including migrants – are considered particularly affected by the effects of climate change; however, it is often difficult to provide them with information (see Chapter 4.1) (high agreement, medium evidence).

The government responded to the problematic health literacy situation in Austria in several ways; the enhancement of health literacy of the Austrian population was recognized as a task of the *Zielsteuerung Gesundheit* (Target-based Health Governance) health reform (Zielsteuerung-Gesundheit, 2017), and the Austrian Health Literacy Alliance (Österreichische Plattform Gesundheitskompetenz; ÖPGK) was established as a platform for implementing the reform. This created major strategic prerequisites within the scope of the health care system to tackle the health challenges posed by

climate change. However, in the available documents on health literacy, no explicit references to the health effects of climate change have been made so far.

The Action Plan of the Austrian Strategy for Adaptation to Climate Change (BMLFUW, 2017b) also repeatedly refers to the necessity of implementing educational measures and coordinated information campaigns, in particular with regard to health. Providing the appropriate financial means as well as showing greater appreciation for awareness-raising (health literacy) and recognizing the long-term benefit of these measures are called for. However, direct cooperation as part of the health literacy measures of the health care system have not been established yet. Currently, the Austrian Health Literacy Alliance (ÖPGK) consists of institutions of the health care system at federal level, the ministries for education, youth, social affairs and sports, but not the ministry for sustainability.

Options for action

Enhancing health literacy in the population is to be regarded as one of the most crucial and effective strategies of adaptation to the health impacts of climate change. It can be assumed that climate change information that is not target group-specific and motivating has little impact and/or does not reach the particularly affected population groups (Uhl et al., 2017). This results in the following options for action for improving health literacy among the population:

1. Enhancing intersectoral cooperation of all competent health and climate-related authorities both at federal and provincial levels, in particular within the scope of the Austrian Health Literacy Alliance (ÖPGK) to finance and develop climate-related health literacy of the population (high agreement, medium evidence).
2. Initiating information campaigns for health promotion and prevention that support climate-relevant health behavior and conditions, in particular in the field of active mobility (e. g. physical activities, such as cycling and walking in everyday life), healthy eating and recreation in local green areas. Favorable framework conditions provided by municipalities, employers, care and social institutions, schools, etc. will enhance this effort. For the personal approach to be effective, it takes supportive framework conditions (e. g. bicycle paths, meals in canteen kitchens) (high agreement, medium evidence). In this context, the health *co-benefits* of climate protection and adaptation strategies provide promising opportunities (Sauerborn et al., 2009).
3. Teaching health care professionals systematically about climate-specific health care issues as part of their education and further training (see Chapter 4.3) because these can both identify health concerns of individuals and groups and give appropriate individualized advice and assistance (see Chapter 5.2.3). Moreover, they may initiate health promotion and prevention measures related to the social context in the local environment, for example in cooperation with the municipalities, if necessary. Finally, raising awareness among health care professionals is necessary to reduce the GHG emissions from medical treatments (e. g. by avoiding unnecessary diagnoses or therapies) (see Chapters 4.2 and 5.4.4) (high agreement, low evidence). This requires action to be taken by medical universities, universities of applied sciences and Medical Chambers. In this context, it is problematic that the pharmaceutical industry funds medical training programs in Austria with considerable amounts (Hintringer et al., 2015) so that medical training that is independent from outside interests and focuses on avoiding unnecessary diagnoses and therapies is hardly possible.
4. Systematic development of health information systems which are independent of industrial and economic interests. These systems can most efficiently be implemented by existing nationwide information services, such as AGES or the public health portal (Gesundheit.gv.at, 2018) and can draw on the standards set by *Gute Gesundheitsinformation Österreich* (Good Health Information Austria) (ÖPGK & BMGF, 2017) published by ÖPGK.
5. Personal discussions or consultations are paramount when it comes to teaching climate-friendly health behavior (e. g. active mobility and healthy diet). In this context, health care professionals, most notably physicians, are called upon to act as "personal health advocates".
6. Measures aimed to improve the quality of dialogue in medical treatment (education and training) can be extended to also include the climate change aspect (BMGF, 2016b; Gallé et al., 2017; Nowak et al., 2016). Developing the organizational and financial framework ("organizational health literacy") (Abrams et al., 2014; Brach et al., 2012; Pelikan, 2017) is a necessary prerequisite for implementing target group-specific information services. The implementation in youth centers and in open youth work can serve as an example of how a target group-specific approach can be implemented (Wieczorek et al., 2017).
7. Promoting targeted educational measures in schools (curricula and teaching practice) to encourage children and adolescents to adopt a climate- and health-conscious lifestyle (BMLFUW, 2017b). This is of importance for health literacy of future generations (McDaid, 2016), for fair and equal opportunities and for the ability of society to adapt to climate change in the long run. Based on the development of environmental literacy in Austria (Eder & Hofmann, 2012) or environmental literacy (Scholz, 2011) programs in the US school system (ELTF, 2015), the close intertwining of environmental, climate and health literacy would be the next step in this context.
8. People with low education levels, people with low income, older people living alone – also including migrants – and people with disabilities are considered particularly affected by the effects of climate change; however, they need adequate information for promoting their health literacy. Raising (transcultural) awareness among the stakeholders

in the health and social sector for these risk groups is important to be able to gain access to them, if need be (specific communication skills and tools) (GeKo-Wien, 2018) (high agreement, medium evidence).

9. Research on the information needs and the best information media for the particularly affected population groups as well as regular evaluation of existing services (e. g. health and meteorological warning systems), also with regard to the changing information search behavior of the population (e. g. new media or multilingualism) to get access to these groups effectively (medium agreement, medium evidence).

5.4 Common Fields of Action for Health and Climate Protection

The fields of action presented here can generate significant benefits both in terms of health and climate. The associated options for action equally address conditions and behavior. Conditions are constantly being shaped through political instruments, such as infrastructure facilities, price incentives, taxes and regulatory measures. Here, readjustment is possible by making actions beneficial to climate and health more attractive and actions harmful to climate and health less attractive. Such changed conditions can bring about behavioral changes, in particular if accompanied by information that explains the background and thus promotes the climate and health literacy of the population. Nonetheless, certain options for action may cause resistance among some stakeholders but also consumers for different reasons. Therefore, integrating the stakeholders and the population is a basic prerequisite for successful climate and health policy to avoid unnecessary disadvantages and take full advantage of the envisaged benefits when it comes to the concrete definition of measures. This must be accompanied by research, both before and during implementation. Acceptance is also a question of framing: The following explanations aim at well-justified measures only, not at the framing under which they are introduced.

5.4.1 Healthy and Climate-friendly Diet

Critical trends

According to Lang (2017), sustainable diets need to be low carbon, low in embedded water, biodiversity protecting, nutritious, safe, available and affordable to all; they must also be high quality and culturally appropriate and derived from labor processes which are just and fairly rewarded without dumping external costs elsewhere in the economy (high agreement, robust evidence). Diets that meet these criteria also contribute to meeting the SDGs (Lang, 2017). Lang believes that the responsibility for achieving these goals set by the community of states lies with the governments, which can exert influence on both methods of production and dietary habits. While the discussion in this Assessment Report focuses on climate and health, the interactions with other development goals should not be forgotten.

From a climate perspective:

- Globally, about one quarter of all GHG emissions comes from the agricultural sector (Steinfeld et al., 2006; Edenhofer et al., 2014; Tubiello et al., 2014). Livestock production alone accounts for 18 percent of global GHG emissions (Tubiello et al., 2014).
- It is uncontested that vegetable products have a significantly lower climate impact per nutritional value than animal products, in particular meat (Schlatzer, 2011).
- It is also undisputed that, for reasons of climate protection, food and feed production that is associated with humus formation (e. g. organic farming) is preferable to any other production method (high agreement, robust evidence).
- The use of mineral fertilizers is damaging to climate because of the high energy consumption required for production and the resulting humus depletion (high agreement, robust evidence).
- Organic farming could make an important contribution to climate protection as well as maintenance of soil fertility and biodiversity (see Zaller, 2018) (high agreement, medium evidence); its contribution to health is also uncontested due to the reduced use of pesticides and antibiotics.
- The United Nations Sustainable Development Goal (SDG) 2, Target 4, deals with food production and climate: "By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality". Success is measured in terms of proportion of agricultural area under productive and sustainable agriculture.
- About 580,000 tons of avoidable food waste is generated each year in Austria, with households, retail as well as hotels and restaurants being responsible for more than half of it (Hietler & Pladerer, 2017) (high agreement, medium evidence). The date of minimum durability, which is largely misinterpreted as an "expiry date", contributes to this wastage (Pladerer et al., 2016).

From a health perspective:

- The share of cereals, fruit and vegetables should be markedly higher because meat consumption in Austria significantly exceeds the healthy levels recommended by the Austrian food pyramid (BMGF, 2018), with amounts for adult males, for example, exceeding the recommended levels threefold (BMGF, 2017e) (high agreement, robust evidence). In the Canadian Guiding Principles and Recommendations, the recommended proportion of other animal products, in particular milk, was reduced based on recent evidence (Food Guide Consultation, 2018).
- Palm oil, which is widely used in the food industry for its physical properties and low cost production, is a special topic that is much debated at the moment. The deforestation and drainage of rain forests due to the production of palm oil results in a climate-damaging carbon debt, in addition to many other catastrophic environmental effects it causes (Fargione et al., 2008). Health concerns have already been voiced as to whether there is a heightened risk of developing diabetes, atherosclerosis and cancer (see, for example, the EFSA warning (2018) concerning food processing contaminants, with palm oil containing particularly high levels of these contaminants. Hence, palm oil is neither climate-friendly nor healthy (high agreement, robust evidence).

The measures aimed at promoting a healthy diet are largely consistent with those necessary from a climate perspective (and with sustainability in mind). While documents on climate policy often mention health co-benefits, reference to the climate issue is usually missing in health policy documents (Bürger, 2017).

Options for action

1. Individuals could start paying more attention to the quantity and quality of food as well as the share of meat. A more balanced diet would also be a step towards meeting Target 2 of Sustainable Development Goal 2, "2.2 *By 2030, end all forms of malnutrition*", because in Austria approximately 30 percent of all boys and approximately 25 percent of all girls aged 8 to 9 years are malnourished (overweight) (BMGF, 2017h).
2. Consumers will take decisions that are beneficial to climate and health more readily if, on the one hand, they have better health and climate literacy and, on the other hand, the price structure accommodates such decisions (see Chapter 4.5.2) (medium agreement, medium evidence). The price structure could be influenced, for example, by tying funding more strongly to humus formation and the protection of biodiversity, climate-friendliness and health-related quality criteria, by GHG weighted taxes on all categories of food (Springmann, Mason-D'Croz et al. 2016b) or by stricter animal welfare regulations or meat taxes (Weisz et al. in progress; see Haas et al., 2017; ClimBHealth, 2017), thus reflecting the true costs.
3. In terms of nutrition, a reduction in meat consumption has the largest positive effects on climate and health (Friel et al., 2009; Scarborough, 2014; Scarborough, Clarke et al., 2010; Scarborough, Nnoaham et al., 2010; Scarborough et al., 2012; Tilman & Clark, 2014; Springmann, Mason-D'Croz et al., 2016b). A more plant-based diet could significantly reduce the global mortality rate and dramatically decrease dietary greenhouse gas emissions (see Chapter 4.5.2; Springmann, Mason-D'Croz et al., 2016b) (high agreement, robust evidence). For instance, animal products play an important role in the risk of developing diabetes mellitus type II and cardiovascular diseases. This is why measures aimed at reducing meat consumption, such as raising the price of meat but also making fruits and vegetables more appealing, are of particular importance (high agreement, robust evidence). Gender-related measures to lower the above-average intake of meat by certain groups of persons (e. g. men) are also advisable (see below, see Chapter 4.5.2).
4. At present, the framework conditions of the food sector largely include only regulations on acute damage. This could be changed in the interest of prevention in health care and climate protection. Under the current system, profits stay with the food industry, while the costs of unhealthy diets are borne by the public through the social and health care system (Springmann, Mason-D'Croz et al., 2016b). Leverage points: The German Environment Agency (UBA) called for a reduction of the value-added tax rate on fruit and vegetables for the benefit of climate and health (Köder & Burger, 2017). To achieve a more sustainable form of livestock production, FAO has long been arguing the case for taxes and fees internalizing the costs of environmental damages (FAO, 2009). With a tax on animal food products corresponding to EUR 60 per ton CO_2-eq, agricultural GHG emissions in the EU-27 could be reduced by approximately 32 million tons of CO_2-eq, or 7 percent (with EUR 120 per ton CO_2-eq approximately 14 percent)(Wirsenius et al., 2011).
5. Any changes in the framework conditions (conditions) should be accompanied by information campaigns strengthening the consumers' personal responsibility by means of comprehensible and extensive quality labels (ecological, social, health-related) (high agreement, low evidence). The reversal of marking obligations would constitute a more radical step: rather than putting labels on products that are climate-friendly and healthy, labeling products for being harmful to health or the climate.
6. Initiatives such as food cooperatives, urban gardening, community-supported agriculture, leased land, neighborhood gardens, guerilla gardening, self-harvest fields, etc. are additional attractive approaches to change conditions and behavior. Although not mandatory, these initiatives mostly offer organic, regional and seasonal products, mainly cereals, fruit and vegetables. As a rule, those par-

ticipating in such initiatives eat a healthier diet, and farmers have more leeway when it comes to selecting plants and cultivation methods (medium agreement, low evidence). In order to harness the potential of such initiatives aimed at achieving more health and climate protection, there should be more environments and freedom for experiments, where bureaucracy responds to challenges in innovative ways. There will be ways, other than by trade licenses, to ensure that taxes are paid or standards are met, which do not question the existence of such initiatives per se. In doing so, lessons could be learnt for the upcoming transformation processes at the level of society as a whole (high agreement, low evidence).

7. Another important approach would be to switch to serving healthy and more climate-friendly food in state institutions such as schools, kindergartens, military barracks, canteens, hospitals and retirement homes as well as in hotels and restaurants (high agreement, medium evidence). Such change can be implemented with costs remaining substantially the same (Daxbeck et al., 2011). The first results of a school experiment showed that students were noticeably building muscle and losing fat, even if they were not very much into the topic of nutrition, and at the same time practicing joyful physical activity (Widhalm, 2018). In hotels and restaurants, smaller portions with the option of having a second helping, at least one vegetarian meal and a jug of tap water on each table would be important contributions. To add a further leverage point, it would be advisable to enhance health and climate literacy in the education and further training of cooks, dietitians and purchasers for large food and restaurant chains.
8. State policies should have a vital interest in climate-friendly and healthy dietary behavior as the effects of pursuing climate targets, increased labor productivity and lower health care expenses may contribute to lower public spending (Springmann, Godfray et al., 2016; Keogh-Brown et al., 2012; see Scarborough, Nnoaham et al., 2010).
9. Like in other research fields, it is paramount that research strictly focuses on the public interest, i.e. also on fields where no economic benefit is to be expected, and detached from commercial interests (high agreement, medium evidence). First important steps in medical research could include greater transparency with regard to funding, research questions and approaches and evaluation methods as well as the selection and size of samples.

5.4.2 Healthy and Climate-friendly Mobility

Critical trends

Transport is a highly relevant sector when it comes to climate and health. It accounts for 29 percent of Austria's greenhouse gas emissions, more than 98 percent of which are caused by road transport. Some 44 percent of road transport emissions in 2015 were caused by freight transport and some 56 percent by passenger transport. Emissions have risen by 60 percent since 1990 (reference year of the Kyoto protocol) with a disproportionate increase in freight transport (Umweltbundesamt, 2018).

Low fuel prices in Austria have led to the increased purchase of fuel for vehicles passing through Austria as well as in border regions. The petroleum tax generated in the process every year is equivalent to the costs of emission permits required for the entire first Kyoto commitment period (EUR 500 to 600 million). In this case, fiscal-policy interests are running counter to Austria's climate protection goals (Stagl et al., 2014).

Necessary as it may be, the technological transition from fossil fuel vehicles towards electric vehicles alone will not suffice to meet the goals, it rather gives rise to new challenges, e.g. how to provide sufficient volumes of green electricity (and cover peak loads), properly dispose of used batteries, and have economically disadvantaged segments of the population participate in electric mobility in spite of higher purchase prices. In addition, problems such as the risks of accidents, particulate pollution from tire and brake wear as well as resuspension, traffic jams and land use for road infrastructure remain unresolved. It is especially the high space requirement of multi-track vehicles in urban areas which stands in the way of creating more recreational and green areas needed to improve city residents' quality of life, particularly when temperatures are rising. The health potential of the transformation is by no means fully harnessed by electric mobility (high agreement, robust evidence).

In any case, a shift in the modal split (share of different modes of transport in the total traffic volume) for passengers and freight needs to be part of the solution. The City of Vienna demonstrated that this is possible, with the modal share of private motorized transport having dropped from 35 percent in 1995 to 31 percent in 2013/14. The shift towards an increased use of public transport was not least owed to the price cut for the annual pass for unlimited travel on Vienna's public transport system with simultaneous parking management and an expansion of public transportation services (Tomschy et al., 2016). Amid an increasing overall traffic volume (i.e. stronger growth of private motorized transport), passenger cars account for the largest modal share in Austria at 57 percent (2013/14), which marks an increase

over 1995 (51 %). The use of trains and buses has remained almost steady at 18 percent in 2013/14, compared to 17 percent in 1995. Walking has declined altogether. While the modal share of cycling has clearly risen in this period (from 2.3 to 5.2 billion passenger-kilometers), walking has declined slightly in total (from 5.2 to 5.1 billion passenger kilometers). However, the share of trips has notably dropped from 26.9 percent to 17.4 percent, which means that the number of distances walked has declined, but their length has increased. Freight transport has shown the opposite trend with a significantly higher volume of transport on the road. These developments are to be viewed in light of increased transportation activity (passenger cars: 66 %, heavy-duty vehicles: 73 %) (Umweltbundesamt, 2017).

From a climate perspective, reducing air traffic, which is not covered by the Paris Climate Agreement, would be an extremely important element (high agreement, robust evidence). The voluntary measures adopted by the International Civil Aviation Organization at Montreal are far from being sufficient to reach the overarching goal (Carey, 2016). According to ICAO's forecasts, global air traffic will grow by 300 to 700 percent by 2050 (European Commission, 2017), a development that, if it indeed came to pass, would counteract the Paris Agreement. In Austria, the number of take-offs and landings has shrunk since approximately 2008 (Stadt Wien, 2018b). The number of passengers carried in Austrian air traffic has more than tripled since 1990 (Statistik Austria, 2017c).

As human settlement structures such as physical layouts of residential dwellings, workplaces, shopping malls, schools, hospitals or retirement homes are major determinants for traffic volumes, a legal framework and guidelines for spatial and urban planning are required to reduce mobility volumes or design attractive paths for pedestrians and cyclists (high agreement, robust evidence).

More than 40 percent of the respondents in Austrian surveys say that they feel annoyed by noise. One of the main sources of noise pollution is traffic, with road traffic being the dominant cause. According to the Micro-census conducted by Statistics Austria, however, its share has somewhat declined in the past few years (Statistik Austria, 2017b).

Poor air quality in cities and alpine valleys and basins remains a problem in Austria, especially with regard to nitrogen dioxide emissions – with this in mind, the EU initiated infringement proceedings against Austria in 2016. Particulate matter emissions also occasionally exceed their limit values; ozone surpassed its limit values at some 50 percent of the monitoring stations. Road traffic, in particular diesel-powered vehicles, is the major source of nitrogen oxides, particulate matter and ozone precursors (high agreement, robust evidence).

The diesel emissions scandal revealed, on the one hand, that due to favorable driving cycles, officially published passenger car emissions are way lower than the emission levels actually metered and, on the other hand, that even the latter levels were only achieved in test cycles thanks to manipulative software. Even though the inappropriateness of the cycles used to measure emissions had repeatedly been pointed out, more realistic levels were laid down in the pertinent EU legislation only after the scandal broke. Charges brought in the course of dieselgate dealt mostly with the loss in value car owners suffered while the increased contribution to air pollution and climate change have basically gone unpunished. The very system that facilitates such kind of scandals, with virtually all manufacturers having manipulated emissions, was hardly a subject in the debate. The only measure introduced after the scandal was stricter checks.

Health effects

The reduction of fossil fuel-based mobility and the modal shift towards active mobility reduce pollution and environmental noise caused by of passenger and freight transport and lead to more health-promoting physical exercise. This can help reduce obesity and people being overweight as well as the risk of cardiovascular diseases, respiratory diseases and cancer, but also insomnia and mental illnesses, which leads to higher life expectancy and an extension of healthy life years (high agreement, medium evidence). At the same time, increased health service costs and sick leave can be avoided (Haas et al., 2017; Mueller et al., 2015; Wolkinger et al., 2018) (see Chapter 4.5.3).

The change in terminology from "unmotorized traffic" to "active mobility" as the experts put it shows the evolution of cycling and walking from being private leisure activities to widely accepted everyday means of transport. The biggest health effect is usually observed in cyclists who consequently cycle to work every day (Laeremans et al., 2017).

Cities and human settlements that are designed with a view to active mobility rather than being car-friendly are beneficial to social contacts and, as a consequence, to well-being and health. It is obvious that this can have an effect on the integration of elderly people and migrants (medium agreement, medium evidence). Even crime rates decline in cities designed in a more people-friendly way as compared to cities focused on motorized traffic (Wegener & Horvath, 2017). The increased share of active mobility in urban areas allows for the decommissioning of roads and parking spaces in exchange for pervious surfaces and green areas, for example by planting trees, and creates an important opportunity for alleviating the effect of heat islands (Stiles et al., 2014; Hagen & Gasienica-Wawrytko, 2015).

The reduction of air traffic volumes involves a reduction of harmful emissions such as particulate matter, secondary sulphate aerosols and secondary nitrate aerosols (Rojo, 2007; Yim et al., 2013) as well as of noise and the elevated risk of transmitting infectious diseases (Mangili & Gendreau, 2005).

Options for action

1. The technological transition from fossil fuel vehicles to alternatively-powered vehicles is necessary but will not suffice as a lone measure; it requires the determined development of attractive offerings for active types of mobility as well as public transportation in order to achieve the climate goals and to harness health benefits (high agreement, medium evidence).
2. Greenhouse gas and air pollutants emissions of alternative propulsion systems (battery electric vehicles and fuel cell vehicles, biogas vehicles and hybrid electric vehicles) register below the emission levels of the latest generation of fossil fuel passenger cars even with production factored in (high agreement, robust evidence). The electrification of road vehicles could help achieve deep reductions in greenhouse gas and nitrogen oxide emissions, particularly if green power were used (Fritz et al., 2017). When it comes to particulate pollution, the reduction is not as deep due to resuspension and tire and break wear.
3. The noise issue could be significantly alleviated by electric vehicles driving at low speed (high agreement, robust evidence). With passenger cars, however, the rolling noise starting at 30 to 40 km/h is predominant. The noise reduction applies especially to electric trucks. In the changeover period low-noise vehicles pose an increased safety risk (high agreement, low evidence). With regard to freight trains, noise-differentiated track access charges have been in introduced in Austria, offering an incentive to switch to quiet brakes; this can help reduce noise by up to 10 dB (Fritz et al., 2017).
4. SDG 3.6, indicator 3.6.1 calls for halving the number of road traffic deaths by 2020. According to statistics published by the Federal Ministry of the Interior (Statistik Austria, 2018b), the death rate due to road traffic accidents has been going down, and reaching the goal is challenging but not impossible. The share of cars, the distances travelled and the actual driving speed are to be reduced. By reducing the speed several issues can be addressed: lowering the number of road fatalities, pollutant emissions, CO_2 emissions and noise (high agreement, robust evidence).
5. The public response to the numerous initiatives taken by the civil society and Austrian municipalities suggests a change of heart in people with regard to owning a car: car sharing, bike rentals, cargo bicycles etc. are in high demand (medium agreement, robust evidence). These changes could be harnessed to create legislation with a view to sustainability and health protection by making active mobility and sharing clearly more attractive than private motorized transport. For example, low-emission zones and parking spaces could be reserved for active mobility and electric vehicles, or car sharing companies could be required to operate only electric vehicles to receive a permit.
6. Adequate spatial planning and traffic management can ensure that typical everyday routes (to school, work, shopping, leisure activities) are short and safe, allowing children to walk by themselves (high agreement, robust evidence). Bike racks very close to the destination provide an incentive to embrace active mobility, especially if parking

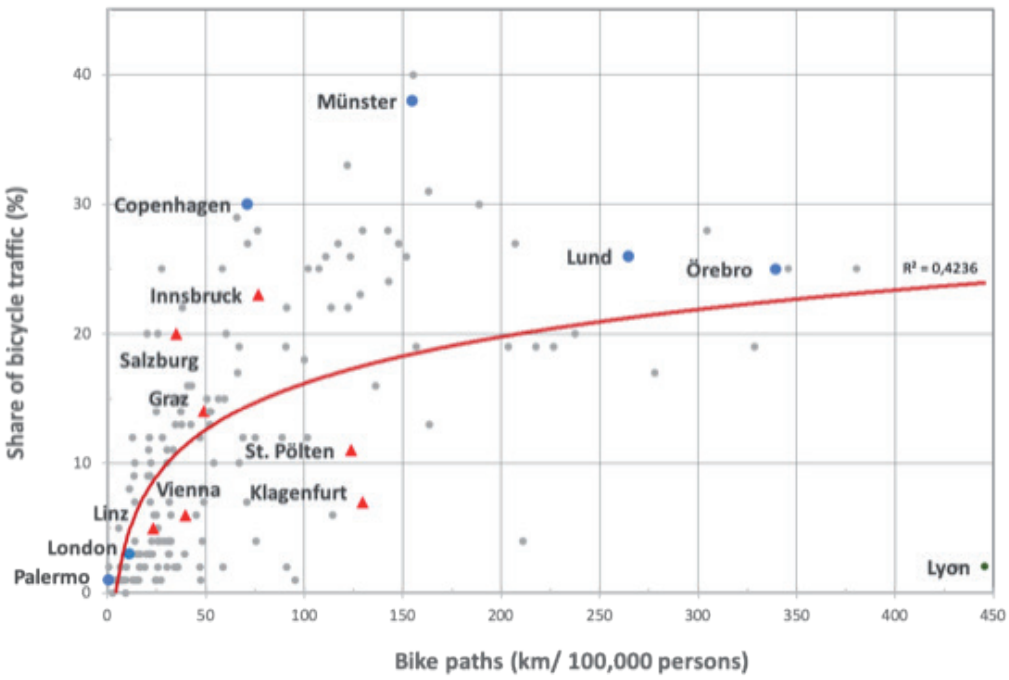


Fig. 5.2: Share of bicycle traffic relative to the length of bike paths in 167 European cities. Data sources: BMLFUW, 2015; Mueller et. al., 2018; websites of provincial capitals.

spaces for passenger cars involve considerably longer routes on foot. In response to extreme weather conditions, for example, shade-providing trees, shelters, seating areas and drinking-water fountains are helpful in adapting to climate change (Pucher & Buehler, 2008). A smart combination of spatial planning and parking management may lower the attractiveness of shopping centers situated on the outskirts or in-between human settlements and thus reduce transportation routes. Cities where people can walk or ride their bikes to shops and which offer places to interact and linger produce less emissions and have a more stress-free and healthier feel than car-friendly cities (Knoflacher, 2013) (high agreement, robust evidence).

7. Transportation experts suggest that a true change of mind will only happen when users of private motorized transport have to pay all associated external costs and true-cost pricing in transportation is achieved (Sammer, 2016; Köppl & Steininger, 2004). One approach, for example, would be to make car owners pay a parking fee in the amount of the rent customary for a passenger car parking spot in the respective city. For such financial measures to be more effective, motorized private transport should no longer get preference in regulatory and planning measures for the use of urban areas; for instance, parking spaces and garages should be totally separated from apartments financially, administratively and in terms of their location.
8. A statistical survey of 167 European cities indicates that by extending the bike-path network it is possible to raise the share of bicycle traffic (Fig. 5.2). Funds earmarked for active mobility (e. g. for infrastructure and awareness-raising) are a good prerequisite for promoting it.
9. Cost-benefit analyses conducted in Belgium found that the economic benefit achieved through reduced health care costs was between two and 14 times higher than the initial amount invested in bicycle paths (Buekers et al., 2015). WHO has developed the *Health economic assessment tool* (HEAT) *for cycling and walking*, an online tool to estimate the value of reduced mortality that results from regular walking or cycling, which is intended to make the economic assessment of planned infrastructure projects more comprehensive (WHO Europe, 2017b). Through scenarios of the evidence-based effectiveness of measures, a study on the cities of Graz, Linz and Vienna indicated that the increase of bicycle traffic, even excluding electric mobility, could help reduce deaths per 100,000 population by close to 60 and CO_2-eq emissions from passenger traffic by almost 50 percent, whilst curbing annual health care spending by almost EUR 1 million per 100,000 population. This could be achieved through a tried and tested mix of policies combining the establishment of strolling zones, reduced-traffic zones, the construction of new bike paths and infrastructure, an increase in service frequencies of public transport and cheaper fares in urban/rural transit. If complemented by electric mobility and provided that power generation goes carbon-neutral, all of these measures could save 100 percent of CO_2-eq emissions and prevent 70 to 80 deaths per 100,000 inhabitants (Haas et al., 2017; Wolkinger et al., 2018) (high agreement, robust evidence).
10. In order to tap the enormous potential of the mobility sector for the benefit of climate protection and health promotion equally, the competent departments of municipal, provincial and federal institutions need to work together. Smooth cooperation requires most of all the provision of the necessary resources and capacities for the exchange of information and opinions (Wegener & Horvath, 2017) (high agreement, medium evidence).

5.4.3 Healthy and Climate-friendly Housing

Critical trends

The housing situation is one of the main factors that contribute to health and well-being (see also SDG goal 3). At the same time, construction and housing are important factors in the climate debate as, on the one hand, they cause greenhouse gas emissions and may create lock-in effects due to the long life of buildings, and on the other hand, they are heavily affected by climate change and require adaptation measures (high agreement, robust evidence). Moreover, this is an important business sector, also in terms of jobs (high agreement, robust evidence). Buildings account for only roughly 10 percent of Austria's greenhouse gas emissions with numbers declining, but the housing stock has shown a straight-line growth since 1961. Approximately 87 percent of residential buildings are single-family and duplex houses which entail car-related emissions and a multiple area of sealed surface; only 13 percent contain three or more units (BMLFUW, 2017a).

The expected climate change and altered comfort conditions will inevitably lead to changes in building equipment (e. g. installation of air conditioning and shading systems). The design of residential and commercial buildings and infrastructural facilities has a significant impact on other areas such as mobility and leisure behaviors (BMLFUW, 2017a).

In cities in particular, increasing summer heat loads during the daytime with no significant drops in temperatures overnight lead to uncomfortable indoor climates and eventual health issues (especially for people in poor health and the elderly as well as children) (high agreement, robust evidence). Buildings with low thermal energy storage capacities, poor thermal insulation and a high share of glass (office buildings) are particularly susceptible to overheating in summer. The orientation and design of buildings is also relevant, with little window exposure to the sun in summer, but high exposure in winter being ideal. The cooling demand and/or the use of alternative measures to reduce room temperatures will rise in

summer (APCC, 2014; Kranzl et al., 2015) (high agreement, robust evidence).

Mild winters are altogether favorable for the building sector, with savings achieved in winter especially in well-insulated buildings still prevailing over the costs of additional cooling energy required during summer heat waves (BMLFUW, 2017a).

Health effects

Alongside heat stress in summer, other health effects need to be taken into account. Noise and air pollution are major well-documented stress factors. Noise levels measured overnight in front of a window which exceed approx. 55 dB(A) may cause health issues (WHO Europe, 2009) such as impaired cardiovascular regulation, mental disorders, reduced cognitive performance or glucose imbalances (WHO, 2009). Such elevated levels occur regularly on busy roads (within cities and on highways and expressways).

Some 80 percent of the energy used in Austrian households is spent on heating and hot water. Efficient heating and hot water systems and systems using renewable energy therefore contribute significantly to climate protection (high agreement, robust evidence). As heating system emissions are released into the ambient air, fossil-fuel powered systems also have an adverse effect on air quality and consequently on people's health in densely populated areas (high agreement, robust evidence). Even simple wood-burning stoves which release fine particles (particulate matter) into the ambient air unfiltered are harmful to people's health.

Electric appliances are indoor sources of heat; the more energy-efficient they are the less waste heat and greenhouse gas emissions they produce.

The neighborhood plays an important role when it comes to health and well-being. It is also crucial for local green areas and nature (see Chapters 5.2.1 and 4.4.3, spatial planning, urban planning and urban green areas) (high agreement, medium evidence).

Options for action

1. Climate-friendly and health-promoting urban planning creates the foundation for healthy and climate-friendly housing. With this in mind, it would make sense to regularly include climatologists and medical doctors in urban planning projects.
2. In the fields of construction and housing, climate change adaptation measures and the reduction of emissions must be viewed as related issues and in combination with transport. Measures aimed at increasing energy efficiency standards of buildings are oftentimes also effective measures combating their overheating (e.g. good thermal insulation, comfort ventilation systems) (BMLFUW, 2017a) (high agreement, robust evidence). This applies also to office buildings, hospitals, hotels, schools, etc. with heating and/or cooling systems. In new buildings, forward-looking technical and spatial planning measures can be taken to avoid adverse effects. "Affordable housing" as advertised by policymakers often turns out to be unaffordable where cheap and poor construction design was applied, as this leads to way higher annual heating costs than in climate-friendly structures. Measures taken at existing buildings often involve considerable expenses (BMLFUW, 2017a), and different ownership structures and interests lead to problems that need to be resolved quickly. When it comes to the energy-oriented restoration of old building stock in Austria, rates are extremely low at less than 1 percent and the quality of renovation is poor as well. An increase both in the quality and the number of premises renovated will help reduce heat stress and produce positive health effects (high agreement, robust evidence). Guidelines, rules and subsidy programs increasingly take climate change into account at different levels, but fail in most cases to pay attention to the close correlation of housing and transport and/or parking spaces.
3. Single-family and duplex houses with their attached garages and parking spaces mean additional sealed surface, materials and energy input, and they imply a long-term commitment to private motorized traffic. As for new buildings, any such constructions should be called into question because of their climate footprint and health implications (high agreement, robust evidence). The level of soil sealing per year in Austria is among the highest in Europe. From 2006 to 2012, an average of 22 hectares of soil was sealed per day, which corresponds to an approximately 10 percent growth rate in sealed surfaces at a population growth of nearly 2 percent (Chemnitz & Weigel, 2015). Attractive alternatives to the deeply rooted aspiration of a good life in a single-family home with a backyard should be made available, for example multi-family homes with green spaces in low-traffic, well-developed areas ensuring a high quality of life, as well as initiatives such as urban gardening, neighborhood gardens or self-harvest fields, which are beneficial not only to climate and health but also foster a community spirit. What is needed now is the development of suitable passive house and energy-plus building standards for larger buildings (high agreement, robust evidence).

5.4.4 Reducing Emissions in the Health Sector

Critical trends

Accounting for 11 percent of the country's GDP (2016) (Statistik Austria, 2018a), Austria's public health care system is of great importance in economic and political terms and for society as a whole. Its purpose is to restore health, but it also contributes directly (e.g. through heating/air conditioning

and power consumption) and indirectly (mainly through the consumption and manufacture of medical products) to climate change (SDU, 2009, 2013), which in turn is harmful to human health and creates a higher demand for health services. At the same time, public funding of health care is stretched to its limits as a result of a rising demand caused by an aging population and technical advancements in medicine (European Commission, 2015).

Its climate impact makes the health care system a material starting point for all kinds of emission reduction policies (Bi & Hansen, 2018; Hernandez & Roberts, 2016; McMichael, 2013; WHO, 2015a; WHO & HCWH, 2009; Bouley et al., 2017). Even though it was mentioned in the Austrian Assessment Report Climate Change (APCC, 2014b), the question of how to avoid emissions from the health care sector was not addressed by Austria's climate and energy strategy. Similarly, the health care reform papers fail to acknowledge its impact on climate change. Austria's Health Targets do refer to sustainably securing and designing the natural resources in Health Target 4 (Gesundheitsziele Österreich, 2018), but they do not point to the fact that it is essential to reduce emissions from the health care sector. Mainly for economic reasons, some Austrian hospitals have implemented energy saving measures, which also led to reduced emissions from hospital operations.

Meanwhile, a great number of predominantly international publications and campaigns deal with environmental and climate protection in health organizations which mostly stop at traditional environmental protection (see Chapter 4.3.2). At an international level, a few carbon footprint studies of individual health sectors have been conducted thus far. They reflect the significance of this sector (in the US, it accounts for 10 percent of GHG emissions (Eckelman & Sherman, 2016)) and also suggest that GHG-related emissions indirectly attributable to the health care sector exceed direct emissions onsite. Of all product groups, GHG emissions from activities associated with the supply chain of pharmaceutical products make up the lion's share (see Chapter 4.3.2) (high agreement, medium evidence). A corresponding study on Austria's health sector is currently underway (ACRP Project Health Footprint, Weisz et al., 2018), but generally speaking, a lot of research is yet to be done in this field.

Health effects

The emissions produced by the health care system (e.g. particulate matter) are also blamed for many disability-adjusted life years (DALYs) (Eckelman & Sherman, 2016). Another issue in the recent discussion is how to avoid unwarranted or non-evidence-based treatments (and hospitalization), which includes avoiding medication errors, multiple or duplicative diagnoses or incorrect assignments (which is when treatment and care do not fit the diagnosis) (McGain & Naylor, 2014). This may not only lead to health-related benefits but also reduce emissions considerably (high agreement, medium evidence).

Options for action

The experience gathered by NHS England (hospital management organization) could serve as a basis for defining strategic options for action for Austria. The key elements are an emission reduction policy (SDU, 2009) and the national competence and coordination office referred to as Sustainable Development Unit (SDU, 2018), which helps implementing the policy by collecting data and launching information campaigns.

1. A specific climate protection (and adaptation) strategy for the health care sector needs to be developed to serve as a political guideline for the stakeholders involved at federal, provincial and organizational levels. This strategy can draw on international models (SDU, 2009, 2014) and the Austrian Health Target 4. It aims to reduce GHG emissions from the public health care system, to keep waste and environmental pollution to a minimum and to make the best possible use of scarce resources. In doing so, it ties in with the reform efforts laid down in *Zielsteuerung Gesundheit* (Target-based Health Governance). Such country-wide development should be spearheaded by the *Bundeszielsteuerungskommission* (Federal Targets Steering Commission) in cooperation with the competent Federal Ministry for Sustainability and Tourism. Within the scope of such a strategy, an impact model and an action plan could, in addition to the targets, be submitted, specifying the key measures that are most important in the long run.
2. The establishment of a national coordination, competence and support unit for sustainability and health modelled on the Sustainable Development Unit has stood the test when other health policies were implemented in Austria (e.g. ÖPGK [*Österreichische Plattform Gesundheitskompetenz*; Austrian Health Literacy Alliance], *Bundesinstitut für Qualität im Gesundheitswesen* [Federal Institute for Quality in Health Care]) and it can help put the strategy into practice by providing guidelines, practice models and public relations assistance.
3. Alongside the implementation of the strategy, a "community of practice" with corresponding participatory structures which allow for an exchange between the various stakeholders needs to be developed and funded. It could be modelled, for example, on ÖPGK in terms of membership structure, networks, conferences, newsletters, etc.
4. Systematically integrating (if necessary compulsory) eco-quality criteria into quality control (KAKuG; Hospitals and Health Resorts Act) and utilizing the incentive mechanisms of the *Gesundheitsqualitätsgesetz* (GQG; Health Care Quality Act) can help and support environmental management departments in hospitals in particular. Measures that have proven successful in the fields of buildings, infrastructure, procurement, waste management, etc. (see, for exam-

ple, projects of ONGKG, 2018; Stadt Wien, 2018a) can be used as a basis for defining quality criteria.

5. International analyses found that significant reductions in GHG emissions could be realized by avoiding unnecessary or non-evidence-based diagnoses and therapies. This helps simultaneously to avoid risks to patient safety and cut health care costs (high agreement, robust evidence). Systematically introducing the "Choosing Wisely" approach (Gogol & Siebenhofer, 2016; Hasenfuß et al., 2016) may prove highly promising in curbing medication errors (examples: AWMF, 2018; Choosing Wisely Canada, 2018; Choosing Wisely UK, 2018). It also holds great potential for mitigating economic and ecological impacts according to first assessments (also applicable to Austria) (Berwick & Hackbarth, 2012; Sprenger et al., 2016) (high agreement, low evidence). A crucial factor in the implementation is what is referred to as shared decision making, i.e. patients and/or their relatives agreeing on diagnosis and treatment with medical staff, something that requires better communication when it comes to patient treatment (ÖPGK, 2018) and enhanced options to base decisions on (Légaré et al., 2016).
6. Consistently implementing the health reform *Zielsteuerung Gesundheit* (Target-based Health Governance), in particular giving priority to multi-disciplinary primary care as well as health promotion and ill-health prevention, can contribute to reducing energy-intensive hospitalizations and, therefore, GHG emissions (high agreement, low evidence). Medical treatments that focus to a greater extent on health promotion (ONGKG, 2018) can help people adopt a more sustainable lifestyle that produces lower emissions (in particular healthier diets and more exercise through active mobility). Handing over a greater number of patients to primary health care centers can reduce GHG emissions as a result of avoiding excessive care and traffic flows (see Bouley et al., 2017). Research accompanying these climate-related effects of the health reform can provide evidence that is relevant to health policy.
7. Alongside the first implementation initiatives, the health care system's impact on climate will need to be analyzed. The complex nature of interdependencies is best analyzed in research projects on international, interprofessional, inter- and transdisciplinary levels with a focus on practical implications. Research in this regard could be funded by the Austrian Climate and Energy Fund, other research promotion institutions, the federal ministries involved, the federal provinces or research institutions in the fields of climate, health, social and economic research.

5.5 System Development and Transformation

5.5.1 Emission Reduction and Climate Change Adaptation Policies in Health Care

Based on the assessments made thus far, specific aspects relevant to transformation and system development can be summarized. Those aspects tie in directly with international health policy, which attributes high priority to the nexus of climate and health (WHO Europe, 2017e), as well as with the concept laid down in the document "Transforming Our World: The 2030 Agenda for Sustainable Development" (United Nations, 2015) and its 17 development goals (SDGs).

In terms of strategy, Austria's health policy has made only selective adaptations to the health effects of climate change and has paid little attention in its planning processes as to what kind of contributions it could make to reducing emissions (see Chapter 5.4.4). The ongoing planning process for implementing Health Target 4 at federal level and individual adaptation strategies at provincial level represent first attempts to systematically connect climate and health.

1. Research and evaluation to adapt the health-related monitoring and early-warning systems to altered climate conditions (communication media and target groups difficult to reach) (high agreement, medium evidence).
2. Including the following climate-related topics in education and further training programs in health professions: new climate-related diseases, developing health and climate literacy, reducing emissions in the health sector (high agreement, low evidence).
3. The partnership-based control structure provided by *Zielsteuerung Gesundheit* (Target-based Health Governance) contains excellent ideas related to climate aspects that have not been exploited so far. This refers in particular to:
   - prioritizing primary care (BMG, 2014; PrimVG, 2017): resilience of the local population, target group-specific health literacy (heat, food safety, new infectious diseases, etc.), supporting early-warning systems and crisis management, vaccination programs (high agreement, medium evidence);
   - prioritizing health promotion and prevention (BMGF, 2016a): sustainable lifestyles – a healthy diet, more exercise through active mobility (high agreement, robust evidence);
   - reorganizing ÖGD (*Öffentlicher Gesundheitsdienst*; Public Health Service): transregional expert pools for medical crisis management to ensure quick intervention at extreme heat events, increased prevalence of allergens, highly contagious diseases and newly emerging infec-

tious diseases (agreement Art. 15a B-VG, 2017, Art. 12) (high agreement, medium evidence).
4. An integrated emission reduction and adaptation strategy for the health care system (see Chapter 5.4.4).
5. A national coordination, competence and support unit for sustainability and health (see Chapter 5.4.4).

5.5.2 Cross-policy Cooperation

For many years, WHO has been calling for a cross-policy approach referred to as "Health in all Policies" or "Governance for health" (Kickbusch & Behrendt, 2013; WHO, 2010b, 2014, 2015a). This builds on the conclusion that, in addition to the health care system, living and working conditions as well as social disparities are key determinants for public health (Dahlgren & Whitehead, 1991). Austria's Health Targets (Gesundheitsziele Österreich, 2018) have also been developed along these ideas. This extremely relevant health-policy approach and its implementation framework until 2032 hold a lot of potential for developing measures on how to cope with the challenges posed by climate change, the demographic development and health risks. The most recent report issued by the Federal Chancellery already takes not of the fact that adhering to the Health Targets will also contribute to achieving a number of SDGs (BKA et al., 2017, p. 15).

Nonetheless, actual cooperation between health policy and climate policy in Austria has been limited to just a few areas. In its latest status report on the environment and health in Europe (WHO Europe, 2017a), WHO Europe also pointed out that the lack of intersectoral cooperation at all levels has been the main obstacle on the road to the successful implementation of climate measures (high agreement, robust evidence).

The EU rightly goes even further in its strategy on adaptation to climate change (European Commission, 2013b) and the related working document on the adaptation to climate change impacts on health (European Commission, 2013a) and calls for the integration of health in climate change adaptation and mitigation policies in all other sectors in order to improve benefits for public health. Here, climate policy is becoming the driving force behind the "Health in all Policies" approach. In Austria, at federal level this cooperation has so far been limited to the competent ministries submitting reports with respect to SDGs to the Federal Chancellery (medium agreement, medium evidence).

Establishing a considerably closer structural link between climate and health policies is key given the comprehensive synergies of these two policy areas, especially in the field of health co-benefits. Climate and health determinants can contribute to strong arguments in other sectors such as education, transport, infrastructure, agriculture, social affairs, research, economy, etc. as well and exert substantial influence on political decisions in these areas for the benefit of the people. This results in the following options for action:

1. Structural linkage of climate policy and health policy: clearly-defined personal assignment of cooperation tasks in the individual ministries involved at management and expert levels; structures for the exchange of climate- and health-related information with a clear political mandate; (extra-funded) assistance through technical expertise and persons with moderation skills for complex participatory negotiations; integration of not only the federal ministries, but also municipalities, the competent provincial units and social security institutions; earmarked funds for joint implementation measures.
2. In terms of substance, it is essential for the health care system to contribute to the development of climate policy strategies and measures in order to identify health aspects and health co-benefits and to harness synergies. Furthermore, expert opinions on climate need to be included in the development of the emission reduction and adaptation strategy for the health care system to be able to clearly highlight climate-relevant aspects (high agreement, medium evidence).
3. The systematic application of the health impact assessment (Amegah et al., 2013; GFA, 2018; Haigh et al., 2015; McMichael, 2013) and advancement to an integrated impact assessment with a view to sustainable development (George & Kirkpatrick, 2007), taking into account the EU Framework Directive on environmental impact assessment (Europäisches Parliament und Rat, 2014), with special emphasis on balancing the various interests (Smith et al., 2010).
4. Taking advantage of enhanced coordination of SDG implementation measures across political areas and responsibilities in various ministries with earmarked funds to make substantial progress.
5. As the urban population is particularly affected by the adverse health effects of climate change, cross-policy cooperation in the field of urban development is required. WHO also considers urban settings as a key environment requiring assistance for public health in conjunction with the 2030 Agenda (SDGs) and health literacy (WHO, 2016).

5.5.3 Transformation Processes, Governance and Implementation

Climate change is a major problem but it is far from being the only global ecological issue. There are others, such as the acidification of oceans, the loss in biodiversity, the phosphorus and nitrogen imbalance, which have the same root cause, i.e. the excessive use of natural resources (Steffen et al., 2015). The resolution adopted by the UN General Assembly named "Transforming Our World: The 2030 Agenda for Sustainable

Development" (United Nations, 2015) and its 17 development goals (SDGs) and 169 targets is an attempt to save the planet while taking social and ecological sustainability aspects into account. Essentially, the main challenge is to facilitate a good life for all within the ecological limits without pitting these demands against each other (United Nations, 2015).

When it comes to climate change, the SDGs refer to the implementation of the Paris Agreement on Climate Change. Compliance with said Agreement requires the use of alternative energies and raw materials (e. g. bioeconomy, resource-efficient production structures and infrastructures) but also a change in production and consumption patterns (energy transition, mobility transition, change of lifestyle, etc.). Such changes have far-reaching repercussions on the economic structure, on competitiveness and the social structure (Görg et al., 2016). Economic growth as we know it has lost its capability of solving problems, mostly because ecological limits are being reached (Meadows et al., 1972; Jackson, 2012; Jackson & Webster, 2016). Within the scope of the "Growth in Transition" project initiated by BMLFUW (now BMNT), those changes are being assessed in cooperation with policymakers, science, the business sector and the civil society (Initiative Wachstum im Wandel, 2018). At the same time, changing demographics and altered rules in business and politics require new concepts in social security systems and in the way people work and live together (see, for example, Hornemann & Steuernagel, 2017). Tackling this complex issue requires a comprehensive strategy that grasps and addresses the interdependencies of the various areas (Görg et al., 2016; Jorgensen et al., 2015). The sum total of changes that are necessary and contingent upon each other is referred to as transformation or transition; no agreement on a uniform term has been reached thus far. In this context, transformation refers to a change process that includes technological changes but goes much further, with the ultimate destination, apart from a few general criteria, yet unknown (medium agreement, low evidence).

One can look at this inevitable transformation of society as an opportunity to create new systems and structures which are better suited to meet the goals of a "good life for all" in other areas as well (Klein, 2014). Observations suggest, however, that the alarming scientific analyses and scenarios are most often followed by rather moderate transformation ideas that do not go further than incremental steps within existing systems. There seems to be an implicit, sometimes explicit, assumption that launching and reinforcing transformation processes works better within existing political, economic, cultural and institutional systems and with dominant players (Brand, 2016). However, comprehensive societal transformation processes typically go hand in hand with revolutionary changes in the political landscape, in the way how work is organized, in ownership structures, world views, social structures and the way how people perceive reality (see, for example, Barth et al., 2016; Fischer-Kowalski & Haas, 2016; Leggewie & Welzer, 2009; Paech, 2012).

To this day, no generally accepted theory has been defined as to how such a deep societal transformation can be accomplished. A concomitant research process may help identify stumbling blocks, risks and compromising developments at an early stage and strengthen positive determinants such as pioneers of change, experiments, learning processes, innovative policies, niches or local sustainability initiatives (Görg et al., 2016). The transformation processes triggered by the necessary climate protection measures but also by digitization and other global trends also lead to changes in the health care system. As part of a social security system that is not considered future-proof in its current state (Hornemann & Steuernagel, 2017), the health care system will also undergo transformational changes in the upcoming years. The current approaches towards change such as the "Health in all policies" principle, the WHO's "Whole of Government" approach or the concept of "Reorienting health services" laid down in the Ottawa Charter are necessary and important steps but they remain within the boundaries of the existing system. A radical change of mind would question a health care system that in all its areas lives on people becoming ill and staying ill. Well-being and health must be the overarching goals, while at the same time safeguarding equal opportunities for all (medium agreement, low evidence).

Naturally, resistance to deep transformation processes is fairly strong; people are always afraid of change especially when there is no clearly-defined vision of the desired outcome. This is particularly true in days of insecurity and rising fears of how to make a living. Concepts like a basic unconditional income (Hornemann & Steuernagel, 2017) or "Common Cause" (Crompton, 2010), an approach for strengthening intrinsic values individually and in society, address this issue in very different ways. Existing systems and Austrian institutions such as the social partnership or federalism show an inherent tendency to be preserved the way they are; something that makes changes difficult. It is no coincidence that the Pope (Francis, 2015) and many others (e. g. Lietaer, 2012) make every individual take responsibility for change. This does not mean that the institutions and the government are free from responsibility – indeed the opposite is true; they need to take primary responsibility, but it is easier to bring about necessary changes where the public opinion is supportive.

At this stage, innovative academic methods come into play which not only observe and analyze systems from an external perspective but also help trigger participatory transformation processes. Case in point is the FAS study "Resilienz Monitor Austria" (Katzmair, 2015), which first defined the characteristics of resilient systems in cooperation with competent persons from the administrative sector, business and science and subsequently had them rate the resilience of their own systems. In this study, the as-is resilience was determined – by the way, with a relatively favorable outcome in the case of pandemics but a poor outcome when it comes to climate change –, which then sparked a learning process among the responsible individuals which led to an increased resilience of the system (medium agreement, medium evidence).

5.5.4 Monitoring, Knowledge Gaps and the Need for Research

Data on climate change and its impacts

Measurements and data are a key basis for any kind of research and evidence-based policy as described, for example, in the Public Health Action Cycle (Rosenbrock & Hartung, 2011). Austria has a fairly sound base of climate-related data in the narrower sense, but it is still necessary to increase the data density and to enlarge the database in geographical terms and in terms of substance (CCCA, 2017). This is primarily due to the fact that meteorologists have chosen locations for measuring weather and climate conditions that are highly standardized and representative of larger regions and can thus serve to answer meteorological questions. Little attention was paid to capturing those parameters that reflect people's well-being when combined. Data volumes gathered in human settlements and in particular in places where people spend some time, i.e. streets, public places, courtyards, are low. Measuring points in cities are preferably located on the outskirts and in parks (high agreement, robust evidence).

A comprehensive study on the costs of inaction (Steininger et al., 2015) clearly suggests that the demand for systematically recording the impacts of climate change in just about all areas is considerable (not only) in Austria. Data is also needed as a basis for making decisions on what climate change adaptation actions should be taken. The CCCA Science Plan 2017 (CCCA, 2017) therefore calls for the development and implementation of a concept for monitoring climate change impacts in all areas of the natural environment. Test areas should be established and operated in order to get a better understanding of the complex interaction of direct and indirect impacts of climate change.

Data on public health and demography

In Austria, a well-established registration system has been in place for a long time that yields comprehensive demographic data. The number of people who are not registered is fairly low but those people often belong to economically more vulnerable groups of society and have specific health problems (high agreement, robust evidence).

The medical history of individuals is very well documented in Austria, and the digitization of medical records will help merge scattered data and standardize files. The merging of data records from extramural and intramural patient care is still in its early stages but has been defined as an objective for the current reform period of the health care system. The extramural area in particular is lacking transparency, which is why the badly needed (valid) morbidity register is not available and the reliable monitoring of climate change effects on health is not possible. Usually scientists get access to the data but the strict privacy regulations require an ethics commission to examine research projects first.

There are rules on how to document treatments carried out in individual hospitals and other health care institutions, and some of these records are even accessible to the public. But there is no (anonymized) data on successful and unsuccessful treatments, in particular over longer periods of time (high agreement, robust evidence).

What is even more relevant to the current issue is the lack of data on the patients' environment. What is their education? What do they do for a living? What is their family situation like? How much money do they have? Where have they been for how long? What is their home environment like? And their social environment? What are the hottest temperatures they get in their homes? What kind of noise are they exposed to? And many more. There is no doubt that routinely collecting this data takes a lot of work, but like the medical history it is part of a patient description and contributes to a broad picture of society, climate change and health. The electronic health record should from now on allow the compilation of some of this data. However, to get an all-encompassing picture we would need a comprehensive population register like in Scandinavia (e.g. for Sweden: SND, 2017) (high agreement, medium evidence), which with some envy is globally referred to as a goldmine when it comes to health data and social data (Webster, 2014).

Knowledge gap and the need for research

This section focuses on knowledge gaps resulting from the interdependencies of climate change, demography and health.

This category includes first of all comparatively straightforward tasks such as determining the emissions of health services and identifying mitigation measures. So far, only few life cycle analyses of medical products and product groups, in particular of medical drugs, are available. And there is the question of ecological side effects/climate impacts of medical treatments in relation to the treatment outcome: Is the success of a treatment worth the damage, measured, for example, in disability adjusted life years (DALYs)?

Along similar lines, there is a need for analyses of the efficiency of monitoring and early-warning mechanisms regarding the mitigation of health impacts: How can the success of early-warning mechanisms be quantified? Little research has been done so far on the trauma caused by extreme weather events. Being constantly confronted with the seemingly unavoidable climate disaster and the powerlessness people feel may create fertile ground for mental illnesses such as anxiety disorders and depression (Swim et al., 2009; Searle & Gow, 2010; Bourque & Willox, 2014; Ojala, 2012).

In urban areas in particular, the health effects of particulate matter of different compositions and origins need to be researched, and also the complex connection of people's growing sensitivity and climate change, for climate change adapta-

tion measures can only be devised and implemented on the basis of combined and integrated observations.

With buildings becoming increasingly hi-tech in order to improve energy efficiency, it will be necessary to analyze whether this will cause new health issues and how much net GHG emissions are actually saved, taking into account the carbon footprint.

Organic farming started more than 90 years ago with interest in quality food growing ever since. Against this backdrop, it has become obvious even in Austria that a changeover to organic farming will be necessary to achieve the objectives laid down in the Paris Climate Agreement, and to this end, conclusive scientific data on the effects of organic versus conventional food on nutrient content and health is required. Just like in other areas of health research with enormous economic implications, such investigations would preferably be carried out by independent bodies staffed with international members who follow test and trial designs that had been thoroughly discussed, funded by national or supranational institutions in order to increase acceptance of the outcome.

Both medical as well as agricultural research would do well to improve transparency with regard to their scientific problem-solving techniques, test and trial designs, and also sources of funding, since research and education in both disciplines are largely funded by interest groups. Where the only academic chair for animal nutrition at a university is funded by a large animal feed corporation or where investigations into the health effects of chocolate are carried out by an academic chair funded by "Mars", doubts may arise – whether justified or not – with regard to the necessary independence in the choice of research topics and the outcome. The increasing dependence of research on the business sector and the resulting non-transparent interests are frequently considered problematic at universities (e. g. Zürcher Appell, 2013) and in society (Kreiß, 2015). Climate researchers are also familiar with publications and opinions influenced by the industry (Oreskes & Conway, 2009). They have responded with wide-scale, transparent assessments (IPCC, APCC).

Many aspects of adaptation to the health effects of climate change but also of emission reduction are closely connected to the social, cultural and regional context and the preconditions of people and communities. Research taking a differentiated view of the socio-economic conditions of health and climate protection is therefore essential.

Economic evaluations of health benefits and (health care) costs associated with specific (climate protection) measures are very scarce and have therefore not been considered in the assessment (Steininger et al., 2015). The enormous cost increases due to technological and pharmaceutical advancements which may prolong a person's life but oftentimes fail to ensure a sound quality of life require a public discussion of emotional and ethical implications.

Another research area is finding suitable transformation pathways which are also accepted by the public. Even if there is no dispute as to which goals to set for both health and climate strategies – e. g. the lowering of meat consumption, a reduction in air traffic or an urban density increase – no answer has yet been provided as to how the respective measures can be formulated to win over the public and decision-makers and to avoid disadvantages and make the most of opportunities.

This is immediately followed by the question of how to adequately communicate complex and often inconvenient connections. International literature provides very different, sometimes even contradicting approaches which badly need to be streamlined: Are we lacking adequate visions? Is it about proper framing (Wehling, 2016)? Is it exclusively about elite nudges, i.e. requirements of groups perceived to be elitist (Roberts, 2017)? Or do even scientists themselves not believe what they know (Horn, 2014)? Even though these questions refer to the climate problem in the literature quoted, they apply similarly to the health issue (Holmes et al., 2017), e. g. to so-called lifestyle diseases, which would require a change of habits to prevent or to cure them rather than medication.

Finally, at least scientists should adopt a more radical way of thinking as criticized by Brand (2016). Hardly any scientific research has been done on the health care system as a socio-economic stakeholder, but it would be a key starting point for a transformation. When it comes to transformation, practical implementation is currently ahead of science; numerous systems and structures are emerging all over the world (in Austria as well) and are tested in the field: The gamut runs from alternative monetary systems and freecycle networks to community banks, insurance companies and housing groups to slow food and slow city movements and transition towns. Researchers are called upon to pool their knowledge and skills in inter- and transdisciplinary projects and to investigate the relevance of those trends to human health with climate change in mind, to proactively estimate their potential, to address stumbling blocks and beneficial factors and, if need be, point out undesirable trends at an early stage and simultaneously develop a transformation theory able to support the difficult process of finding a feasible way. Transformation can be accelerated where this expertise is integrated into research-based teaching programs and thus into education and further training programs as well as into political processes.

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Austrian Special Report
Health, Demography and Climate Change
Summary for Policymakers and Synthesis

The state of knowledge in brief

The effects of climate change on health are already being felt today and can be classified as an increasing threat to health in Austria. The most severe and far-reaching effects to be expected are health impacts due to heat. Also changes in ecosystems which influence the distribution, frequency, types and severity of pollen allergies and vector-borne infectious diseases and alter the patterns of precipitation and storms will threaten health. Furthermore, changing demographic structure and composition including population aging and migration can increase the number of people exposed to health risks. The health impacts of climate change are not distributed evenly across population sub-groups as older people, for instance, are physiologically more susceptible to extreme heat whilst migrants with lower socioeconomic resources dispose of a reduced adaptive capacity.

However, there are many options for action to mitigate the health effects of climate change and reduce vulnerability. These range from better information of hard-to-reach people to urban planning measures in the case of increasing heat, better management of highly allergenic plants as well as an integrated event documentation of extreme weather events for more targeted measures with strengthened self-provisioning. For the early detection of infectious diseases, health competencies of the population and health personnel must be improved and climate-related health inequalities can also be avoided by improving health literacy.

At the same time, efforts to mitigate climate change can also yield health benefits and these health co-benefits of climate change mitigation should be emphasised when promoting climate actions. In terms of nutrition, reducing excessive consumption of meat can both improve health and reduce greenhouse gas (GHG) emissions. With respect to mobility, a shift towards more active mobility such as walking and cycling and public transport, especially in cities, reduces health-related pollutants and noise pollution, encourages healthy movement and reduces GHG emissions. Reduction of climate-relevant air traffic also diminishes adverse health effects. With regard to housing, a large proportion of single-family and duplex houses in newly developed residential areas is to be challenged as it uses a lot of space, materials and energy. Attractive apartment buildings as an alternative to a house in a green area require funding and promotion by health-enhancing and climate-friendly urban planning. Thermal renovation reduces the heat stress during the summer half-year. Likewise, health-care activities contribute to climate change and reducing the carbon footprint of the healthcare sector is necessary. In fact, pharmaceutical products are responsible for a major share of the carbon footprint. Avoiding unnecessary diagnostics and therapies, for instance, can reduce GHG emissions, risks for patients and health-related costs.

To initiate a transformation in the intersection of climate and health requires cross-policy cooperation of climate and health policy and is an appealing opportunity to simultaneously implement Austria's Health Targets, the Paris Climate Agreement and the United Nations Sustainable Development Goals. With transformation research and research-led teaching, science can accelerate transformative development paths and foster new interdisciplinary solutions to problems.

The Austrian Special Report (ASR18) has been developed in an IPCC-like process with numerous review steps. Compliance with procedural standards was monitored by the *Austrian Panel on Climate Change (APCC)*. The aim of the report is to provide complete scientific knowledge which is coherent and contributes to an integrative, transparent and policy-relevant analyses for Austria.

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